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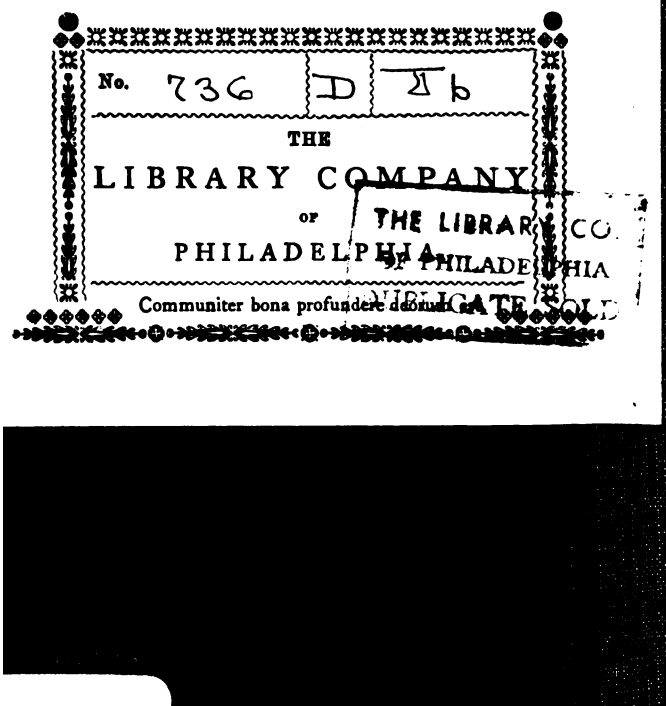
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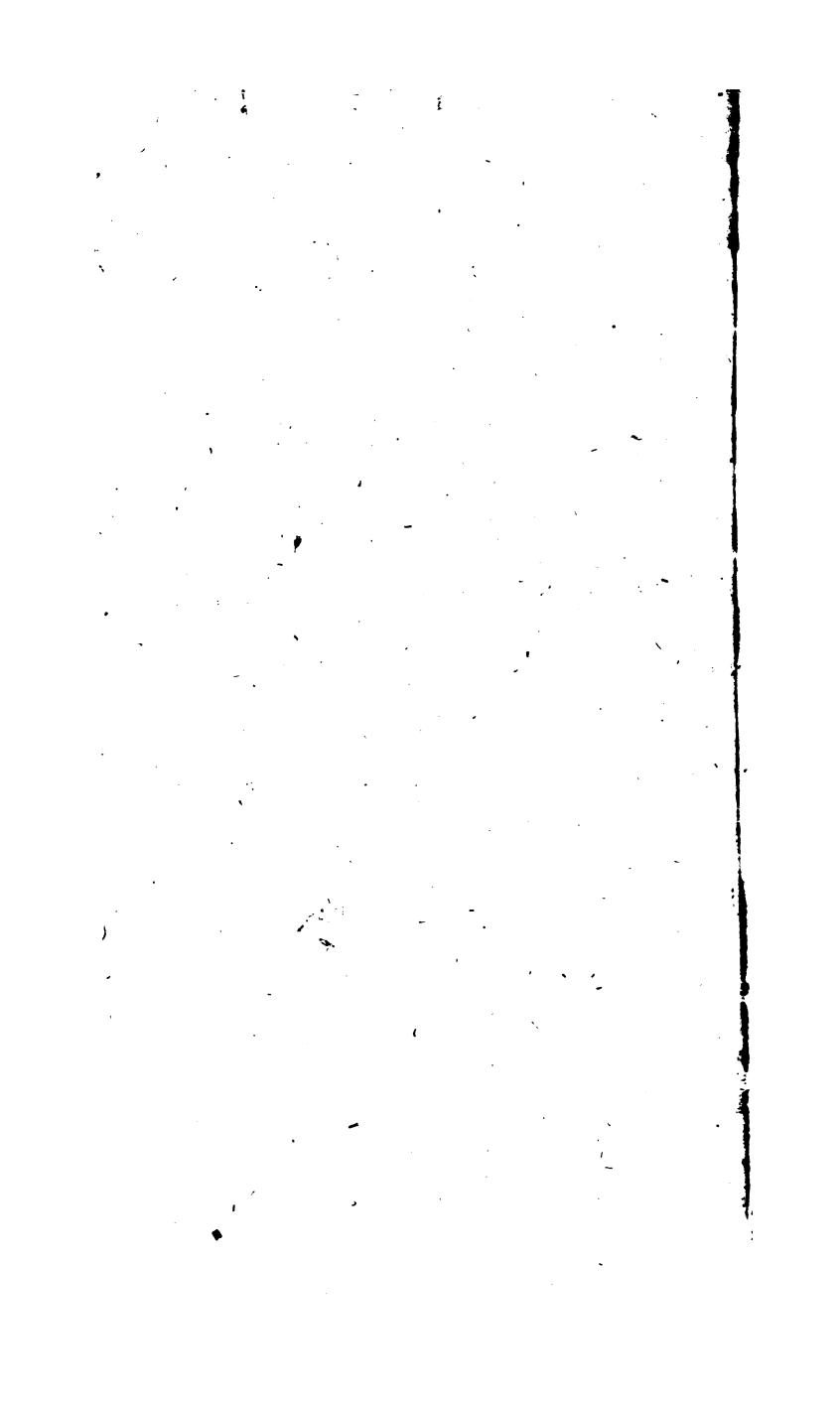








THE
H I S T O R Y
OF THE
RISE AND PROGRESS
OF
G E O G R A P H Y.



THE
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OF THE
RISE AND PROGRESS
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G E O G R A P H Y.

BY

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L O N D O N.

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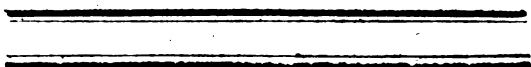
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ON THE
RISE AND PROGRESS
OF
GEOGRAPHY.

IT must be obvious to every one,
that ARTS and SCIENCES, when re-
presented only in their more ripened
State of Improvement, can never com-
municate a full Degree of Information,
unless at the same time the ruder
Stages through which they passed, be-
fore they arrived at that Degree of Per-
fection,

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section, are minutely traced and known. A young Architect would never attain to be Master of his Art, if he had only seen Buildings, however magnificent, after the Fabricks were completed. For then he could have no Opportunity of observing the Breadth or Depth of the Foundations which are necessary for carrying so great a Weight; he could know nothing of the Figure and Contrivance of the Frames by which the Arches and Vaultings were executed; the Manner of fixing those Beams which bind the different Parts of the Walls and Roof together, and all the various Application of Tools and Engines, Ladders and Scaffolding, by means of which the Efforts of Art and Labour were united to complete the Pile. For when the Superstructure

is

is finished, then all these various Implements of Mechanism are removed, like Rubbish, from the Spot, and many of the ablest Exertions of Skill in the Builder lie covered and out of Sight.

Geography therefore is, in this Respect, like every other Science, whose imperfect Beginnings ought to be traced, and the Time and Manner pointed out in which it received its gradual Improvements. For though it is far from my Intention to prefix any System of Geography before the few Maps which are now published by way of Illustration of my Tables of Chronology; yet having found but little Satisfaction in any one Author, though I have looked into most of them who have professedly wrote upon this Subject,

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ject, I have, for my own Amusement, collected and digested from different Writers, both ancient and modern, such Particulars as I thought most interesting for giving the Outline of this History of Geography, hoping that the Leisure and Abilities of others, more conversant in this Branch of Knowledge, may be prompted to supply more amply this *Desideratum* in the History of Learning.

It appears that the early Geographers, being destitute of mathematical instruments and of astronomical Observations, began first to determine the Situation of Places according to Climates; and they were led to fix upon those Climates from the Form and Colour of certain Animals which were
to

to be found in those different Countries. The Appearance of *Negroes*, or what they called *Æthiopians*, and of the larger sized Animals, such as the Rhinoceros and Elephants, suggested to them the Line of Division where the Limits of the Torrid Zone began towards the North, and ended towards the South. For Reason, said they, points out to us, that similar Things appear in the same Temperature of the Elements; and that whether they were Animals or Plants, they are produced according to the similar State of the Air or Climate under the same Parallels, or a like Situation equally distant from either Pole*.

* Ptolemæi Geogr. lib. 1. cap. 9.

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This groffer Manner of dividing their Climates, must be considered as the first rude Outline of Geography in the more illiterate Ages of the World. For another Method was soon adopted by the Egyptians and Babylonians, which was the determining the Situation of Places, or their Distance from the Equator, by observing *the Length of their longest and shortest Days*. And that this Observation might be performed with some Accuracy, they made use of a Species of perpendicular Sundials, having a Stilus or *Gnomon* erected upon a horizontal Plane, by which they were enabled to measure the Length or Shortness of the Shadow, in proportion to the Height of the Stilus.

It

OF GEOGRAPHY. 7

It is difficult to say which of these two Nations are intitled to the Credit of this Invention. Herodotus * tells us, *that the Greeks first learned the Pale, the Gnomon, and the twelve Divisions of the Day, from the Babylonians.* But in opposition to this it may be observed, that the Merit of this Invention of the Gnomon in Greece, is ascribed by Pliny † and Diogenes Laertius, to the astronomical School of Miletus, and particularly to Anaximander and Anaximenes, the Disciples of Thales; and there is reason to believe that this

* Herodotus, lib. 2. p. 145. Ed. H. Steph.

† Pliny, lib. 2. cap. 76. Umbrarum hanc rationem & quem vocant Gnomonice invenit Anaximenes Milefius Anaximandri Discipulus, primusque Horologium, quod appellant Sciotericon Lacedæmone ostendit.

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Method of Observation was well known to Thales himself. For though the actual Erection of a Gnomon was an Honour reserved for one of his immediate Successors, who placed at Lacedemon the first Sun-dial upon that Construction that was seen in Greece*; yet it may be presumed at the same time, that Thales, who had travelled into Egypt, where he learned both his Geometry and Astronomy, might bring from thence the Idea and Principle of this Instrument of Observation; for Diogenes Laertius particularly mentions, *That he was the first who found out the Passage of the Sun from Tropic to*

* Diogenes Laertius in Anaximandro, lib. 2.

Ευρε δὲ καὶ γνόμενα πρῶτος, ἔκαὶ εἰσεν ἐπὶ τῶν σκιωδῶν ἐν Λακεδαίμονι τροπὰς τε καὶ ἰσημερίας σημαίνοντα.

Tropic.

Tropick *. But by what Instrument could this be determined unless by the Gnomon? For *the Astrolab* and *the Armillary Circles* are generally believed to have been invented by some of the later Greek Astronomers who flourished under the Ptolemys; such as Timocharis, Aristillus, or Eratosthenes.

Thales is likewise said to have been the Author of two Books, one *on the Tropick*, and one *on the Equinox*, the exact Times of which he probably determined by the Shadows of the Gnomon; and by this he was naturally led to another of his Discoveries, which was the Division of the Year into *its four*

* Πρώτος δὲ καὶ τὴν ἀπὸ τροπῆς ἐπὶ τροπὴν παροδοῦ
ἔστι. Diog Laert. lib. 1. § 24.

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Seasons, which was a Consequence of his finding the particular Days when the Sun appeared to be in the Tropics and in the Equinox.

His Division of the Year into 365 Days, was undoubtedly brought by him from Egypt, as it is universally allowed* to have been an Egyptian Discovery prior to his Time, being ascribed to the second Mercury, surnamed Trismegistus, who is supposed † to have lived about 50 Years after the Exodus, according to Eusebius. And Pliny

* Herodotus, lib. 2. p. 48. Macrobi Saturn. 1. 12. Strabo, lib. 17. p. 816.

† Eusebius in Chronico. Syncelli Chronograph. p. 123. Marsham Chronicon ad Sæc. x. p. 245. Ed. Lips. 1676.

tells

tells us expressly, that the Discovery of this Length of the Year by the Addition of the five Days and a Quarter to the 360, was made by observing when *the Shadow returned to its Marks* *; which is a clear Proof that it was done by the Use of a Gnomon. And that the taking the Lengths of the Shadow, by way of Calculation, was an Idea familiar to Thales, appears from his first inventing the Method of determining the Height of the Pyramids

* *Deinde Solis Meatum esse partium trecentarum, sed ut Observatio Umbrarum ejus redeat ad Notas, quinos annis dies adjici, superque quartam partem diei. Pliny, lib. 2. cap. 8.* It is proper to observe here, that the odd Quarter of a Day, though known to the Egyptians, was not added till under the Reign of the Emperor Augustus, in the Year 25 before Christ.

by their Shadow, at that exact Instant of Time in the Day when the Shadow of a Man is found to be equal to his Height*.

It does not therefore seem to be an improbable Supposition, that this Method of observing by the Gnomon was originally imported from Egypt, where it was known long before this Dawn of the Greek Learning; for it has been the Opinion of several eminent Writers †, that their Pyramids and Obelisks, which

* Diogenes Laertius in Thalete, lib. 1. § 27.

† Idemque insinuant Obelisci & Pyramides antiquissimæ, non ad Ornatum solum aut Pompam erectæ in Ægypto, sed etiam ad captandam ope Umbrarum Altitudinem Solis. Riccioli Almagest. Tom. 1. Præf. ix. Cassini de l'Origine & du Progres de l'Astronomie, p. 13.

to common Travellers appeared to be Buildings merely of Ornament and Magnificence, were really Sun-dials upon a larger Scale, by which the Variation of the Length of the Shadow, in proportion to its Height, could be taken with a greater Degree of Accuracy. And to confirm this Opinion, it was found upon Examination by M. de Chazelles * in 1694, that the two Sides, both of the larger and smaller Pyramids, were placed exactly North and South, so as to be true meridian Lines even at this Day, and the other two Sides stood East and West; which is a clear Proof that even in those early Times in which they were built, they

* M. Fontenelle's *Eloge de M. de Chazelles*, dans les *Mémoires de l'Académie pour 1710*.

were

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were so contrived by the Egyptians, to stand in the direction of the four cardinal Points of the Heavens for the Purposes of their astronomical Observations.

It is not my present Intention to register all the particular Discoveries of *Astronomy*, but only to explain such of them as are intimately connected with *the Progress of Geography*; for their Advances were so often made by the same Steps, that the one is not to be clearly understood without the other.

From the Days of Thales and his immediate Successors, who flourished in the Sixth Century before Christ, there seems to have been little done towards the solid Improvement of *Geography*

graphy for two hundred Years, till the Establishment of the famous Astronomical School of Alexandria. For we have scarce any Fragments remaining of the School of Pythagoras; though at the same time it must be owned, that their having known the true System of the World by placing the Sun in the Center, and giving the Earth both the diurnal and annual Revolutions, are Proofs that their Knowledge of this must have been established by clear and accurate Observations.

There is, however, an astronomical Observation mentioned during this Period, and it is indeed the first Greek one that is on Record, and is preserved

to

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to us by Ptolemy *, which is that of Meton and Euctemon, who observed the Summer Solstice at Athens, during the Archonship of Apseudes, upon the 21st of the Egyptian Month Phamenoth, in the Morning, being the 27th of June, 432 Years before Christ. This Observation was made with a View of determining the Beginning of their Cycle of XIX Years, which commenced upon the New Moon of the 15th of July immediately succeeding (being exactly 18 Days after the Solstice), and fell, according to Diodorus †, upon the 13th of the Athenian Month Scirophorion.

* Mathem. Syntax. lib. 3. cap. 2. p. 62.

† Diodorus Siculus, lib. 12. p. 305.

This

This solstitial Observation must have given Meton and Euctemon an Opportunity of determining the Latitude of Athens at the same time, had they but known the simple Manner of drawing the Conclusion; for as the Length of the Shadow of the Gnomon was narrowly watched at the Crisis of the Solstice, the Proportion of that to the Height of the Gnomon was easily known, by which the Angle of the Sun's Altitude was given. And though the Sun's greatest Declination was then very inaccurately known, being by some * supposed to be 24° , and by others † $23^{\circ} 51'$, which is only found at present to be $23^{\circ} 28' 10''$, yet still the Latitude of Athens might

* Strabo ad finem, lib. 2. & Vitruvius, lib. 9. cap. 8. & Messahala Arabs, lib. 2. Astrolabii, ex Indorum Observatione.

† Ptolemy, Math. Syntax. lib. 1. cap. 11. p. 18.
have

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have been deduced within the Limitations of this Error ; making at the same time Allowances for the gross Manner in which Altitudes were determined without proper Instruments, and without the Solutions of Trigonometry, which appears to have been unknown till the Age of Hipparchus, by whom it was first introduced *.

It

* TRIGONOMETRY appears to have been first introduced by Hipparchus, according to Theon, in his Commentary on the Almagest, lib. 1. cap. 9. p. 39. where treating upon *the Quantity of Right Lines in a Circle*, and having premised that Circles are supposed to be divided into 360 Parts, the Diameter into 120, and the Radius into 60, he adds the following Words:

“ The Method of finding the Right Lines (or
“ Chords) in a Circle, is demonstrated by Hip-
“ parchus in Twelve Books, and after him by Me-
“ nelaus

It would seem that Timocharis and
Aristillus, who began to observe 295
Years

“ nelaus in Six Books.—It is a thing much to
“ be admired (continues he) that this Man (viz.
“ Hipparchus) with so little Difficulty, and by
“ a few, and those easy Theorems, has made the
“ Discovery of their Quantities; and after this,
“ by certain short Lemmata, he demonstrated
“ a few, and those the most useful of the
“ Theorems, for obtaining, the Quantities of
“ these Right Lines; and then consequentially,
“ by these very Theorems, he has demonstrated
“ the Method of investigating a Canon or
“ Table, by which we may not only find from
“ the Data, without any Investigation, the
“ Magnitudes laid down, but likewise by a
“ linear Demonstration we may investigate
“ them; so that if any graphical Error should
“ be introduced in the Numbers given by the
“ Canon, we may with great Readiness rectify
“ them by means of the Projection.”

Ptolemy

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Years before Christ, were the first who introduced the Manner of determining the

Ptolemy, in his *Almagest*, or *Mathem. Syntax.* lib. 1. cap. 9. has shewn us this Operation by finding the real Quantities of the Pentagons and other regular Figures inscribed in a Circle, and from thence deduces his Method of calculating a Table of Subtenses or Chords, to every 30' of the Circle, which he subjoins to this Chapter.

But when they came to apply these to the Purposes of Trigonometry, their Manner of Calculation was very tedious by the *Subtenses of double Arcs* instead of *Sines*, which was an After-Invention of the Arabians, appearing first in the Writings of Albategni, and their Cases were solved by a Composition of Ratios betwixt six different Magnitudes, from which it was intitled, *The Canon of the six Quantities*, alluding to the three Sides and the three Angles contained in all Triangles

the Positions of the Stars, *according to their Longitudes and Latitudes*, taken with respect

Triangles whatever, both plain and spherical*.

In this embarrassed State it continued till towards the Middle of the Tenth Century, when it was reduced by the Arabians to a clearer and more simple Method. For besides the Introduction of Sines already mentioned, all the various Propositions were reduced to three plain Theorems by Geber ben Aphla, the Astronomer of Seville, and which are contained in his Preface to his Commentary on the Almagest, which was published by Petreius of Norimberg in 1633.

There were two Cases in spherical Triangles, however, to which these three Theorems did not extend; which are, when the three Sides are given, and the Angles required; or when the three

* Menelaus, lib. 3. Prop. 1. Ptolemy Almagest. lib. 1. cap. 12. p. 18. & lib. 2. p. 35. Montucla's Histoire de Mathematiques, Tome 1. p. 358.

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respect to the Equator. This we know from Ptolemy, who has preserved many of

three Angles are given and the Sides are required. And the Merit of the Solution of them was reserved for Regiomontanus in the Middle of the Fifteenth Century. Trigonometry is also indebted to him, and his Master Purbachius, for having calculated a Table of Sines to every Degree and Minute of the Quadrant. It was upon this Occasion, in 1464, that Regiomontanus is supposed to have introduced, for the first time, *Decimal Arithmetic* in his *Trigonometrical Canons*, in the Room of the *Sexagesimal Parts* which had formerly been in use; and this he did, as Wallis says, *silently and unobserved*. See Wallis's Preface to his *Algebra*, and also p. 31. Regiomontanus likewise introduced the Use and Application of Tangents; and near 100 Years after this, about 1560, Rheticus added to these the Use of Secants in Trigonometry, and composed new Tables of Sines, Tangents, and Secants, calculated not only for Degrees and Minutes, but from ten Seconds to ten Seconds.

The

of their Observations in his *Almagest* *; one in particular is well known,

The greatest Addition, however, to this Branch of Mathematicks, was made by John Napier of Merchiston, who introduced two new Theorems, which rendered the Solution of all the Cases of spherical Triangles still more easy and simple than they were before, by what are called *the Five Circular Parts*.

But whatever Reputation he might claim from that Discovery, *his Invention of Logarithms* in 1614, is still much greater and more extensive, and has spread its Influence to every Branch of mathematical Science. Though it must be confessed, that Trigonometry in particular received an infinite Advantage from it, by shortening the tedious Multiplication and Division of natural Sines, which, besides the Consumption of so much Time, rendered the Calculations liable to frequent Errors.

* Ptolemy, *Math. Syntax*. lib. 7. cap. 2 & 3. p. 166, &c.

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as it gave rise to the famous Discovery of the Precession of the Equinoxes; it was that of the Spica in Virgo, which Timocharis found to be 8° West from the autumnal equinoctial Point, and likewise that it was one Degree and two Fifths to the North of the Equator: Both of which were found to be different by Hipparchus, so that this bright Star had shifted its Place with regard to these two Particulars in that Interval of Time elapsed betwixt these two Observations; for in one Case, he only found it to be 6° West from the autumnal equinoctial Point; and in the other, that it was three Fifths of a Degree, or $36'$ to the North of the Equator; but it was found, both by Timocharis and Hipparchus, to have remained nearly at the
Distance

Distance of two Degrees to the South of the Middle of the Zodiac or Ecliptic. From which it naturally appeared reasonable for Hipparchus to suppose that the fixed Stars had a slow Motion round the Poles of the Zodiac: " Yet, as Ptolemy * tells us, " that though inclined to this Opinion, yet Hipparchus says of himself, " *That he hesitated in his own Mind upon the Decision of the Question,* " because the Observations of Timocharis were not to be confidently " depended upon, as being made in a " rough and gross Manner; and that

* Ptolemy Math. Syntax p. 168. Διγάζει δ' ὁμας καθάπερ καὶ αὐτὸς φησί, διὰ τὸ μῆτε τὰς τηρήσεις τῶν περὶ τὸν Τιμόχαρον ἀξιολόγους εἶναι, πάνυ ὀλισχεῖν; ἐλλημμένας, μῆτε τὴν ἐν τῷ μεταξύ χρόνῳ διαφορὰν ἱκανὴν εἶδη γινώσκειν πρὸς βεβαίαια κατὰληψιν.

C

" the

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“ the Interval of Time (though of 150
“ Years and upwards) was not suffi-
“ cient for a clear and certain Com-
“ prehension of that Matter.

There was likewise an additional Reason for this Suspension of Judgment in Hipparchus, which Ptolemy has preserved in another Passage of his *Almagest* *. For he tells us, that Hipparchus had found the greatest Distance of the Spica of Virgo from the autumnal Equinox to be $6^{\circ} 30'$ in the 32d Year of the Third Calippick Period (viz. 146 before Christ) and that he found it to be only $5^{\circ} 15'$ in the 43d Year of the said Period (viz. 135 before Christ); and as he could

* *Mathem. Syntax.* p. 61.

not apprehend that this Star should make a Motion of $1^{\circ} 15'$ in 11 Years, he concluded that this Difference arose from some Inequality in the apparent Motion of the Sun: For though this Variation puzzled him, yet, says Ptolemy *, *He was prompted, from his Love of Truth, to conceal nothing which could tend in the least Degree to carry any Persons to a Suspicion upon his Observations.* But by way of accounting for this, he was induced at one Time to suppose, that this Motion of the fixed Stars in varying their Distance from the equinoctial Point, was confined to such of them as were near the Zodiac, as if this Irregularity was occasioned by

* Βεβουλῆσθαι δὲ μόνον ὑπὸ φιλαληθείας, μὴ σιωπῆσαι τι τῶν εἰσὺς εἰς ὑποψίαν ὀπωσθήποτε δυναμένων ἐνεγκαῖν.

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the Sun, Moon, and Planets, which moved in this Path; and this Ptolemy calls *the first Hypothesis of Hipparchus* *. But this he afterwards relinquished, when he found that the Stars in the great Bear, and others which were at a considerable Distance from the Zodiac; shifted their Places equally with those in the Zodiac, both with regard to the Equator and the equinoctial Colures.

From these Particulars, however, it sufficiently appears, that Timocharis and Aristillus are intitled to a Share of the Merit of Hipparchus, who is so much celebrated for the Boldness of

* Ptolemy Mathem. Syntax. p. 164.

his

his Attempt in numbering the Stars, and ranging them all according to their Situations in the Heavens*. And it is likewise evident, that the Longitudes and Latitudes of the Stars were reckoned from the Equator both by Timocharis and Hipparchus; for it was only after the Precession of the Equinoxes was fully established by Ptolemy, that the Longitudes and Latitudes of the Stars were uniformly,

* Hipparchus—ausus, rem etiam Deo improban, annumerare posteris Stellas, ac *Sidera ad normam expangere, organis excogitatis per quæ Singularum loca atque magnitudines signarent* ut facile discerni posset ex eo, non modo an obirent, nascerenturve, sed an omnino *aliqua transirent moverenturve* — cælo in hæreditate cunctis relicto, si quisquam qui rationem eam caperet, inventus est. Plinii Nat. Hist. lib. 2. cap. 26.

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referred to the Ecliptic. It was then but an easy Transition of Thought in Hipparchus to assort and dispose the different Parts of the Earth according to Latitude and Longitude, being only a new Application or Transposition of that Artifice which was already so happily introduced in the Arrangement of the Constellations, and therefore equally proper to be adopted in tracing the Meridians and Parallels of the Earth.

Strabo has preserved the very Words of Hipparchus, in which he explains his Ideas upon this Subject, being a Fragment extracted from a Treatise of his wrote against Eratosthenes.

“ It

“ It is impossible, says he*, either
 “ for an illiterate Person, or a Man of
 “ Learning, to acquire the necessary
 “ Knowledge of Geography without
 “ an Attention to the Heavens, and
 “ to the Observations of Eclipses.
 “ For whether Alexandria in Egypt is
 “ more Northerly than Babylon, or
 “ more Southerly, or to what Distance
 “ this amounts, cannot be determined
 “ without considering them by their
 “ Climates. In like manner, what
 “ Places lie towards the East, or to-
 “ wards the West; and whether more
 “ or less, no Person can know ac-
 “ curately without comparing the
 “ Eclipses of the Sun and Moon.”
 Thus far Hipparchus.

* Strabo, lib. 1. p. 7.

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As the two Distinctions here pointed out give us the clear Ideas of Latitude and Longitude, it is with great Justice that Hipparchus is universally allowed to have fixed the first solid Foundation of Geography by uniting it to Astronomy, and so rendering its Principles self-evident and invariable*.

Pliny † likewise confirms this, when, after mentioning Thales and Sulpicius Gallus,

* See likewise what Strabo says of Hipparchus, lib. 2. p. 131, 2. Ἀνέγραψε γὰρ, ὡς αὐτὸς φησι, τὰς γιγτομένας ἐν τοῖς ὑρανίοις διαφορὰς καθ' ἑκάστην τῆς γῆς τόπον τῶν ἐν τῇ καθ' ἡμᾶς τελεσισημορίῳν τεταγμένων, λέγων δὲ τὸν ἀπὸ τοῦ ἰσημερινοῦ μέχρι τοῦ βορείου πόλου.

† Utriusque Sideris cursum in sexcentos annos præcinuit Hipparchus, menses gentium, diesque & horas, ac *situs locorum* & visus populorum complexus, ævo teste, haud alio modo quam

Gallus, who had both predicted Eclipses, he adds, *that Hipparchus had foretold the Revolution (of the Eclipses) of the Sun and Moon for 600 Years, comprehending the Months, Days and Hours of different Nations, and the Situation of Places.* By which it would seem, that the Latitudes and Longitudes of these Places were particularly given.

But the fullest and strongest Authority for appropriating this Invention to Hipparchus, is that of Ptolemy in his Geography, lib. 1. cap. 4. who says,
 “ That Hipparchus was the only Au-
 “ thor who had given *the Elevations of*
 “ *the North Pole of a few Cities,* in pro-

quàm Confiliorum Naturæ particeps. Plinii
 Nat. Hist. lib. 2. cap. 12.

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“ portion to the great Number that
“ were to be delineated, and such too,
“ as lay under the same Parallels.
“ Some that came after Hipparchus
“ had given those of other Places that
“ lay upon the same Meridian, be-
“ cause their most favourable Voyages
“ were commonly from North to
“ South; but that most of the Di-
“ stances, and principally those to-
“ wards the East and West, were laid
“ down in a still grosser Manner;
“ not from any Negligence of those
“ who recorded them, but because
“ they had no ready Method of
“ bringing them to a mathematical
“ Exactness; and likewise, because
“ there were not many Eclipses of the
“ Moon which had been observed at
“ different Places at the same Instant
“ of

“ of Time : For it is upon Record,
 “ that an Eclipse, which was observed
 “ at Arbela at Five o’Clock, was
 “ seen at Carthage only at Two
 “ o’Clock ; from which it clearly ap-
 “ peared, what was the Distance of
 “ these two Places towards the East
 “ and West given in equinoctial
 “ Time.”

It is however a little remarkable,
 that though Latitudes and Longitudes
 were in this Manner introduced and
 pointed out by Hipparchus, yet so little
 were they attended to till the Days of
 Ptolemy, that none of the intermediate
 Authors, such as *Strabo**, *Vitruvius*,
 and

* *Strabo*, lib. 2. p. 132. makes indeed an
 Apology for his not having done it, as if the
 C 6 giving

and *Pliny*, who all of them entered into a minute Description of the Geographical Situation of Places according to the Length and Shadows of the Gnomon, have ever given us the least Hint of the Latitude or Longitude of any one Place whatever in the Language of Degrees and Minutes. So common is it in Science to see the Seeds of great and useful Discoveries often lie dormant and neglected for many Years, till there arises some Man of Abilities equal to the first Inventor, who sepa-

giving of these Observations (*which determine Latitudes and Longitudes*) was neither the Business of a Geographer nor a Politician, and that they were besides full of Perplexity; *adding*, that it was sufficient for him to propound from Hipparchus other Things that were more distinguishable and more simple.

rates

rates them, by an original Spirit of Discernment, from the Mass of Matters otherwise of smaller Importance, restores them to their true Point of Light, and often improves them beyond the Ideas with which they were represented in the first Conception.

When the true Principles of Geography were thus pointed out by this new Invention of Latitude and Longitude, it was no Wonder that Maps were from thence made to assume a new Form of Projection essentially different from those in use prior to this Period. It was for this Purpose that the Planisphere, or the Delineation of the Sphere in Plano, is said
by

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by Synesius* to have been introduced by Hipparchus, *in order to preserve the Sameness of the Proportions in the Diversity of the Figure.* It must be owned, however, that the previous Steps to this new Projection of the Sphere, had been in a great Measure made easy by Archimedes, when he invented (at least 50 Years and upwards before Hipparchus) those noble Theorems of his for measuring the Surface of a Sphere and its different Segments; which were none of the least important Discoveries of that great Geometrian.

* Synesius de dono Astrolabii, p. 310. Σφαιρικῆς ἐπιφανείας ἐξάπλωσιν, ταυτότητα λόγων ἐν ἐτερότητι τῶν σχημάτων τηρεσάν. ἠνέξατο μετ', Ἰππαρχος, &c.

We find in Strabo * an Allusion to a spherical Projection in Plano, where the Meridians bended towards each other, so as to make the Figure of a Cone.

For the Maps that were on Record before the Time of Hipparchus, were little more than rude Outlines and topographical Sketches of different Countries; excepting the single Map of Eratosthenes, which I shall explain more particularly, after having given a short Account of those that went before it.

The earliest were those of Sesostris, mentioned by Eustathius in his Epistle

† Strabo. Geogr. lib. 2. p. 117. Ἐν τῷ ἐπιπέδῳ γε ἔ' διόισι πίνακι τὰς ἐνθεῖας μικρὸν συμπύσας ποιεῖν κῶτον τὰς μεσημβρινάς.

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prefixed to his Commentary on Dionysius's *Περὶ ἡγεσις*, who says, “ that this
 “ Egyptian King, having traversed
 “ great Part of the Earth, recorded
 “ his March in Maps, and gave
 “ Copies of his Maps not only to the
 “ Egyptians, but to the Scythians,
 “ to their great Astonishment *.”

The Jews seem to have had Surveyors among them; and some have imagined from this, that they had made a Map of the Holy Land when they gave the different Portions to the Nine Tribes at Shilo, as mentioned in Joshua, Chap. xviii. ver. 4. 8. and 9. For they are there sent to walk through

* Καὶ Σισωστρεῖς δὲ, φασὶν, ὁ Αἰγύπτιος πολλὴν περιηλυθὼς γῆν πιναξί τε δίδωκε τὰς περιόδους, &c. p. 6.
 Ed. H. Steph.

the

the Land, and to describe it; and they are afterwards said *to have described it in Seven Parts in a Book*. And Josephus tells us, that when Joshua sent out People from the different Tribes to measure the Land, he gave them as Companions Persons well instructed in Geometry, who could not be mistaken in the Truth from their Skill *.

He afterwards mentions, that the Men who were sent, being Ten in Number, περιόδυσαντες τε καὶ τιμησάμενοι τὴν γῆν, *going round and estimating the Land*, returned in the seventh Month to Joshua at Shilo.

* Καὶ ἄνδρας τὸς ἐκμίσσησιν τὴν χώραν αὐτῶν ἐξέπεμψεν, παραδὸς αὐτοῖς τινὰς γεωμετρίας ἐπιστήμονας ὅς τε ἀλλήλους οὐκ ἔμελλε λήσεσθαι διὰ τὴν τέχνην. Josephus, lib. v. cap. i. p. 141.

From

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From this, therefore, we may reasonably presume, that a geometrical Survey was then made of the Holy Land; though it does not fully determine whether their Mensuration was only taken down in Numbers, or regularly projected and digested into a Map.

The first Grecian Map on record was that of Anaximander, mentioned by Strabo, lib. 1. p. 7. It has been conjectured by some, that this was a general Map of the then known World, and is imagined to be the one referred to by Hipparchus under the Designation of *the Ancient Map**, which he in a few Particulars preferred to that of Eratosthenes; and some con-

* *Ἀρχαῖος πλανητής*. Strabo, lib. 2. p. 69.

jectured,

jectured, that Anaximander, “ by inventing a Sphere, and introducing a Map, and a Measure of the Circumference of the Sea and Land,” according to Diogenes Laertius, may be * supposed † to be one of the Mathematicians alluded to by Aristotle at the End of his Second Book De Cœlo ‡, who made *the Circumference of the Earth* to be 400,000 Stadia, being the first

* Καὶ γῆς καὶ θαλάσσης περιμέτρον πρώτη εἰργασάμενος.
Lib. 2. § 2.

† Snellius in his *Eratosthenes Batavus*, lib. I. p. 22.

‡ Καὶ τῶν μαθηματικῶν ὅσοι τὸ μέγεθος ἀναλογίζεσθαι περιήλθαι τῆς περιφέρειας, εἰς τετρακόντα λέγουσιν εἶναι μυριάδας σταδίων. Aristoteles, vol. 1. p. 472. Ed. Du Val. This however may be an Argument against that Work being wrote by Aristotle, as Eratosthenes was generally allowed to have been the first who attempted that Mensuration.

grofs

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gross. Calculation that was attempted to be given of that *great Problem in Geography*.

The Map of Aristagoras, Tyrant of Miletus, is likewise particularly worthy of our Attention, because it is so minutely described by Herodotus*, and will give us some Idea of the Nature of the Maps in those early Ages. He tells us, that Aristagoras shewed it to Cleomenes King of Sparta, with a View of inducing him to attack the King of Persia even in his Palace at Susa, in order to restore the Ionians to their ancient Freedom. It was traced upon Brass or Copper, and contained the intermediate Coun-

* Herodotus, Lib. 5. p. 347.

tries

tries which were to be traversed in that March. The Words of Herodotus* must not however be interpreted too literally, as if it contained “the whole Circumference of the Earth, the whole Sea or Ocean, and all the Rivers.” For notwithstanding the Pompousness of the Expression, it may fairly be concluded, from the State of Geography at that Time, that *the Sea* meant only the Mediterranean, and therefore *the Earth* or Land, the Coasts of that Sea, and more particularly the Lesser Asia extended towards the Middle of Persia, and *the Rivers* were the Halys, the Euphrates, and the Tigris, which Herodotus men-

* Έχων χάλκεον πίνακα, ἐν τῇ γῆς ἀπάσης περίοδος
 ἡπείρου, καὶ θάλασσαν ὅτι πάντα καὶ ποταμοὶ πάντες.

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tions as necessary to be crossed in that Expedition. It contained one straight Line, called the Royal Highway, ὁδὸς ἡ Βασιλική, taking in all the Stations or Places of Encampment, which were called σταθμοί, from Sardis to Susa; so that it was an Itinerary, or what the Greeks distinguished by the Title of ἀπογραφὴ σταθμῶν *. There were 111 of these Stations in the whole Extent of this Line or Road, containing 13,500 Stadia, or 450 Parafangæ, which being reduced to the Roman Mile, allowing Eight Stadia to each Mile, amounts to 1687 and

* Strabo, Lib. 2. p. 69. Xenophon has given us the March of the younger Cyrus's Army through these very σταθμοί, and their different Distances in Parafangæ in his *Αναβάσις*, Lib. 1.

One-half Roman Miles; and as it was a March of Ninety Days, Herodotus tells us, that 150 Stadia were allowed for a Day's March, which brings it to Eighteen Roman Miles and Three-fourths for each Day. If we would accommodate this to the English Statute Mile, which contains 5280 Feet, whereas the Roman Mile consisted only of 5000 Feet, it will reduce a Day's March to Eighteen English Statute Miles and One-sixth of a Mile nearly, as the Roman Itinerary Foot differed very little from the present English Foot, as appears from two Itinerary Distances which have been measured; one is the Twenty-five Miles from Bologna to Modena, taken by Ricciolus; and the other, the Twenty-one Miles betwixt London

don and Verulam, found by some Surveyors, quoted by Bernard, to contain 20.37 Miles, of 500 English Feet to a Mile*.

These Itinerary Maps of the Places of Encampment, were indispensably necessary in all Armies. We find Athenæus, in his *Deipnosoph.* Lib. 10. p. 442. quotes Bæton as Author of a Work, intituled *σαθμοι της Αλεξανδρæ πορειας*, *The Encampments of Alexander's March*; and he likewise cites Amyntas, *εν τοις σαθμοις*. And Pliny †, Lib. 6.

* Dr. Murdoch's Enquiries and Conjectures concerning Measures of Length prefixed to Bueching's Geography, Vol. 1. p. 23. Bernardus de Mensuris Antiquis, p. 230, &c.

† Verùm ut terrena demonstratio intelligatur, Alexandri magni vestigiis insistamus, Diogenetus & Bæton ejus mensores scripsere, &c. Epistolæ quoque Regis ipsius consentiunt.

cap. 17. tells us, that Diognetus and Bæton were the Surveyors of his Marches; he then quotes the exact Number of Miles according to their Mensuration, and afterwards confirms it by referring to the Letters of Alexander himself. It likewise appears from Strabo *, that Alexander was very careful in personally examining the Measures of his Surveyors †, having

* Strabo, lib. 2. p. 69.

† There is a Difficulty occurs with regard to the Measures of these Surveyors of Alexander, because Pliny has given the Distances of Places as delivered by them in *the Roman Millia Passuum*, a Mensuration unknown to them, and not in the Greek Stadia. Dodwell had observed this with regard to the Voyages and Distances of Nearchus and Onesicritus, who were Alexander's Admirals; and he sup-
D poses

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having his Descriptions always from the most skilful in every Country. And the same Author acquaints us, that a Copy of this great Monarch's Survey was given by Xenocles his

poses that Pliny took the Reduction of these Distances from Juba, who had abridged their Writings, as alluded to in Pliny, lib. 6. cap. 23. and therefore Juba might perhaps have done the same to the Writings of Bæton and Diogenetus; though this is not quite consistent with a Passage of his, lib. 6. cap. 17. where, after having given their Mensurations in Roman Miles, he adds, *in quibusdam Exemplaribus diversi Numeri reperiuntur*, as if he had been consulting different Manuscripts of the original Writings of these Authors. See Dodwell's *Dissertatio de Nearcho* in Hudson's *Geogr. Minor*, vol. 1. p. 132. But as Pliny gives likewise the Measures of Eratosthenes and other Greek Writers in Roman Miles, it is more probable to suppose they were Reductions made by himself. Pliny, lib. 6. *passim*.

Treasurer

Treasurer to Patrocles the Geographer, who, as Pliny informs us, was Admiral of the Fleets of Seleucus and Antiochus. His Book on Geography is often quoted both by Strabo and Pliny; and it appears that this Author furnished Eratosthenes with the principal Materials and Authorities for constructing the oriental Part of his Map of the then known World. For the Voyages of Patrocles under Seleucus upon the Caspian Sea and elsewhere, were a kind of Supplement to those Measurements given by Boeton and Diognetus already mentioned, and by Nearchus and Onesicritus, the two Admirals who were employed under Alexander, and therefore Pliny * quotes

* Reliqua inde Seleuco Nicatori peragrata sunt. Pliny, lib. 6. cap. 17.

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them immediately after. It appears likewise from the same Passage, that Megasthenes and Dionysius were two Surveyors sent into India by Ptolemy Philadelphus for the Purposes of Geography, and their Authority was sometimes set in opposition to Patrocles by Hipparchus, in his Criticism upon Eratosthenes's Geography *.

I have dwelt a little the longer upon these different Surveys which took their Rise from Alexander's Expedition and Conquests and those of his immediate Successors, because Geography began to assume a new Face and Form from this memorable Æra. For Eratosthenes, who is deservedly considered as the great Father of Chronology,

* Strabo, lib. 2. passim.

employed

employed his eminent Abilities and Learning with equal Success to reduce Geography into a regular System, and laid its Foundation upon clear and solid Principles.

We must do him the Justice to allow, that it was he that first introduced into his Map *a regular Parallel of Latitude* *. It was a geographical Outline traced over certain Places whose longest Day was observed to be exactly of the same Length. He begun it from the Straits of Gibraltar, and it thence passed through the Sicilian Sea, and near the southern Extremities of Peloponnesus, and was continued through the Island of Rhodes and the Bay of Issus, and there entering Cilicia,

* Strabo, lib. 2. initio, p. 67.

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and so crossing the Euphrates and Tigris, was extended to the Mountains of India. By means of this Line he endeavoured to rectify the Errors in the ancient geographical Map, supposed to be that of Anaximander. In drawing this Parallel, he was regulated by observing where the longest Day consisted of fourteen Hours and a Half, which Hipparchus afterwards determined to be the Latitude of 36° , making by this a sort of Translation of it into his own astronomical Language.

This first Parallel through Rhodes, was ever afterwards considered with a Degree of Preference like the Foundation Stone of all the ancient Maps; for it was traced through the Middle of the
Mediterranean.

Mediterranean, whose Coasts were in the Center of the principal Nations of Antiquity, and the Longitude of the then known World was often attempted to be measured in Stadia and Miles, according to the Extent of that Line, by many succeeding Geographers. The running of this Parallel was so happy a Thought in Eratosthenes, that it not only encouraged him to trace upon his Map other Parallels at certain Intervals from his first, such as one through *Alexandria*, another through *Syene*, and another through *Meroe*, but he undertook to trace at Right Angles to these a *Meridian* passing through Rhodes and Alexandria down to Syene and Meroe. And as the Progress he thus made tended naturally to enlarge his Ideas upon this Science, he at-

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tempted a still more arduous Task, which was *to determine the Circumference of the Globe* by an actual Measurement of a Segment of one of its great Circles, making his Computation upon the whole, by uniting certain accurate Observations made in the Heavens, with a corresponding Distance carefully surveyed and taken upon a Meridian of the Earth.

The Segment of the Meridian which he fixed upon for this Purpose, was that between Alexandria and Syene *,

* Cleomedes, lib. 1. p. 53. Martianus Capella, lib. 6. p. 194. tells us, that it was *measured by Ptolemy's Surveyors*, per mensores Regios Ptolemæi, though he seems to have made a Mistake in saying that the Distance was betwixt Syene and Meroe, instead of betwixt Alexandria and Syene.

the

the Distance of which was measured, and found to be 5000 Stadia, and the Angle of the Shadow upon the Scaphia or Sun-dial, which was observed at Alexandria, was equal to the 50th Part of the Circle; for at Syene there was no Shadow from the Gnomon at the Mid-day of the Summer Solstice; and that this might be more accurately taken, they dug a deep Well, which being perpendicular, was completely illuminated at the Bottom when the Sun was vertical *. Though this even was not fully sufficient to give the exact Line of the Tropic, because the Sun was found to be vertical, or to cast no

* Pliny, lib. 2. cap. 73. and lib. 6. cap. 29. Servius ad Eclog. 3. Virgil. Strabo, lib. 17. p. 817.

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Shadow at all for a circular Space of 300 Stadia, because * the Sun's Diameter being equal to 32 Minutes, would therefore appear perpendicular at the same Instant of Time to an Extent of Ground corresponding to that Number of Minutes; and therefore Ricciolus concludes, that this vertical Observation must have extended 150 Stadia on each Side of Syene †.

The Substance of this Account is taken from Cleomedes, who seems to have extracted it literally from Eratosthenes's original Work, intituled *Μετρησεις* ‡, and it is published as such

* Ἀστὲς οὐ γίνονται—καὶ τῶτο γίνεσθαι, λόγος, ἐπὶ τῇ διαμέτρῳ. Cleomedes, lib. 1. p. 53.

† Almagest. vol. 1. lib. 3. cap. 27. p. 163.

‡ Fabricii Biblioth. Græc. vol. 2. p. 477.

at the End of the Oxford Edition of Aratus in 1672, though under the Title of *Μετρον της γης περιφερειας*. By this Account Eratosthenes made the Circumference of the Earth amount only to 250,000 Stadia, whereas a Cloud of original Authors * have uniformly given the Numbers to be 252,000. And to reconcile these two, Dr. Murdoch † has ingeniously supposed, that instead of $7^{\circ} 12'$, the Difference of Latitude was $7^{\circ} 8 \frac{1}{2}'$, which

* Strabo, lib. 2. p. 132. Geminus apud Petav. Uranol. p. 51. Vitruvius, lib. 1. cap. 6. Macrobius, lib. 1. cap. 20. Pliny, lib. 2. cap. 108. Capella, lib. 6. c. 1. Censorinus de die natali, cap. 2.

† Dr. Murdoch's Enquiries concerning Measures of Length, prefixed to Busching's Geogr. vol. 1. p. 27.

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was the $\frac{1}{30}$ $\frac{2}{3}$ th of the Circumference, which would bring the Calculation to 252,000 Stadia, and that Cleomedes neglected the small fractional Part of the Denominator; but that the principal Mistake was in measuring the Distance, and finding it to be 5000 Stadia. Indeed nothing is more common than to find a Confusion of Numbers in the Distances given us by ancient Authors; for though these 5000 Stadia are mentioned as the Distance betwixt Alexandria and Syene by so many Authors, yet we know that Marinus and Ptolemy * did not allow

* Ptolemy. Geogr. lib. I. cap. 11. Καὶ ἔτι τὸ τῆς μὲν μίαν μοῖραν ὄντων ἔστιν ὁ μέγιστος κύκλος μοιρῶν τ' ξ, πηλαιοσίς ἐπὶ τῆς ἐπιφανείας τῆς γῆς ἀπολαμβάνειν σταδίας, ὅτι ταῖς ὁμολογουμέναις ἀναμέτρήσεσι σύμφωνόν ἐστι.

above

above 3600 Stadia to that Distance, as the $7^{\circ} 12'$ amounted exactly to that Number upon the Proportion of 500 Stadia to a Degree, which Ptolemy tells us, *was agreeable to Mensurations that were allowed and acknowledged.* The same Number of 5000 Stadia is said to have been the Distance supposed by Posidonius betwixt Rhodes and Alexandria *, where he had concluded that the Segment of the Meridian was the 48th Part of a great Circle from an Observation of the Star Canopus; whereas Strabo † tells us, that the Seamen only allowed it to

* Cleomedes, lib. 1. p. 51.

† Strabo, lib. 1. p. 25. & lib. 2. p. 125. Pliny, lib. 5. cap. 31. Rhodus—distat ab Alexandria, ut Eratosthenes, cccclxix mill. = 3752 Stadia.

be a Distance of 4000 Stadia, and that Eratosthenes, by his gnomonical Observations, concluded it to be only 3750. In like manner Pliny * tells us that it was 5000 Stadia betwixt Syene and Meroë; but in another Passage †, after mentioning the various Measures of Eratosthenes, Artemidorus and Sebosus, who differed from each other, he adds, *that the Disputes upon that Head had been lately determined by Surveyors sent thither by Nero, who found it to measure 862 Miles*; though from the intermediate Distance there specified, it appears that the collected Numbers give 874, and by multiplying each of these by 8, to increase them

* Lib. 2. cap. 73.

† Pliny, lib. 6. cap. 29.

to Stadia, will give in the first 6896 Stadia, and in the second 6992, both of which differ very materially from 5000 Stadia.

The Investigation of this Problem of the Circumference of the Earth, was essentially necessary for determining the radical Principles of all Maps, and therefore the most eminent of the ancient astronomical Geographers made repeated Endeavours to obtain an Accuracy in this Calculation. Eratosthenes, by making the Circumference as I have already mentioned to be 252,000 Stadia, allowed therefore 700 Stadia to a Degree; which, by the Reduction of 8 Stadia to a Roman

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man Mile of 5000 Feet, amounted to 87 $\frac{1}{2}$ Roman Miles to each Degree.

Hipparchus added 25,000 Stadia to this Measure of Eratosthenes, according to Pliny, lib. 2. cap. 108, though the Observation is not mentioned from which this Conclusion is drawn, which it were to be wished Pliny had done, as it increases the Error of Eratosthenes. This Addition however makes the Circumference to consist of 277,000 Stadia, which was an Allowance of 769 Stadia, or 96 Roman Miles to each Degree *.

* It would seem from two Passages of Strabo, lib. 2. p. 113, & p. 132, as if Hipparchus admitted the Mensuration of Eratosthenes.

Pos-

Possidonius, in like manner, computed the Circumference of the Earth to be 240,000 Stadia, by multiplying 5000 (the supposed Distance betwixt Rhodes and Alexandria) by 48, the Segment of the Meridian according to his Observation betwixt these two Places; but Cleomedes, when he mentions this Conclusion, he adds, *if the Distance is 5000, but if not, in proportion to the Distance* *: And as Eratosthenes had made the Distance to be only 3750 Stadia, and Possidonius resting his Conclusion upon the Deduction from his astronomical Observation of the Arch of the Meridian, it was natural for him to infer, that if

* Cleomedes, lib. 1. p. 52. 'Εάν ᾤσιν ὁ ἀπὸ Ρόδου περιλακισχίλιοι. εἰ δὲ μὴ, πρὸς λόγον τῆ διαστηματικῆς.

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he admitted the Distance given by Eratosthenes to be true, being taken upwards of 170 Years before his Time, upon that Hypothesis, the Circumference of the Earth would be only 180,000 Stadia, as 3750 multiplied by 48 will produce that Number; and indeed Strabo * tells us, that this very Calculation was approved of by Ptolemy. It is for this Reason that he is quoted † as having had two Opinions upon the Quantity of the Circumference of the Earth, and that he was therefore the first Geographer who advanced the Opinion of allowing

* Strabo, lib. 2. p. 95. *ὅτι οὐ Πτολεμαῖος ἐγχειρῶν
περὶ ὅκτω καὶ δέκα μυριάδας ἔσται.*

† Snellii Eratosthenes Batavus, lib. 1. cap. 16.
p. 88. & Riccioli Geogr. lib. 5. cap. 8. p. 144.

only

only 500 Stadia to a Degree, which was afterwards adopted by Marinus and Ptolemy *. By the first Hypothesis, therefore, there would be 666 Stadia, or 83 Roman Miles to a Degree; and by the second, 500 Stadia, or $62\frac{1}{2}$ Roman Miles.

The Discoveries and Improvements of Eratosthenes as a Geographer, have naturally led me to explain these various Mensurations and Calculations of the Circumference of the Earth, which indeed materially affected the Dimensions of all the ancient Maps. It is proper however to observe, that his Map appears to have contained little more than the States of Greece, and the Dominions of the Successors of

* Ptolemy Geogr. lib. 1. cap. 11.

Alexander,

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Alexander, digested from those Surveys already mentioned. He had seen indeed, and has quoted, the Voyages of Pytheas into the great Atlantic Ocean, which gave him some faint Idea of the Western Parts of Europe; but withal so imperfect, that they could not be realised into the Outline of a Chart. Strabo * tells us, that he was extremely ignorant of Spain, Gaul, Germany and Britain, as well as of the Geti and Bastarni; he was equally ignorant of Italy, the Coasts of the Adriatic, of Pontus, and of all the Countries towards the North. And he mentions in another Passage, that Eratosthenes had made the Distance from Epidamnus, or Dyrrachium, on

* Strabo, lib. 2. p. 93.

the Adriatick, to the Bay of Thermæ on the Ægean Sea, quite across Epirus, to be only 900 Stadia, when it was really above 2000 Stadia; and in another Instance, he had enlarged the Distance from Carthage to Alexandria to be 15,000 Stadia, whereas it amounted to no more than 9000 Stadia *.

This was therefore the State of Geography, and the Nature of the Maps, prior to the Discoveries of Hipparchus, who, like an abler Architect, introduced a new Plan of Building more certain in its Principles and more simple in its Construction, and where they might employ without

* Strabo, lib. 2. p. 92.

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waste all the better Parts of the ancient Materials. His Additions tended to make a new and closer Union betwixt Astronomy and Geography, from which they derived mutual Advantages, and widened their Bottom for the Accession of new Improvements.

1

It appears that War has been generally the Occasion of the most accurate Maps of different Countries, and therefore Geography, about this Æra, began to make considerable Advances from the Progress of the Roman Arms. For that great People, as they were *the Conquerors*, so they became *the Surveyors* of the World. In all the Provinces they occupied, we find that

Camps were every where constructed at proper Intervals, and Roads were raised with substantial Materials for an easy Communication between these different Places of Encampment; so that *Civilization* and *Surveying* were carried on *according to System* through the Extent of that large Empire. Every new War produced a new Survey and Itinerary of the Countries where the Scenes of Action passed; so that the Materials of Geography were accumulated by every additional Conquest. Polybius *, when he tells us, that at the Beginning of *the second Punic War*, Hannibal was preparing his Expedition against Rome, by crossing from

* Polybii Historia, lib. 3. p. 193. Ed: Caub. Paris 1609.

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Africa into Spain, and so through Gaul into Italy, he says, *that all these Places were measured or surveyed with the utmost Care by the Romans.*

Without entering into the minuter Execution of the Surveys of particular Provinces with which every Roman General was regularly furnished before his March, and which Vegetius has well described *, I shall only add
a remark-

* Primum itineraria omnia regionum, in quibus bellum geritur, plenissimè debere habere per-scripta: ita ut locorum intervalla non solum passuum numero, sed etiam viarum qualitates perdiscat: compendia, diverticula montes, flumina, ad fidem descripta, consideret: usque eo, ut solertiores duces *itinerà* provinciarum, in quibus necessitas geritur, non tantum *adnotata*, sed etiam *picta*, habuisse firmentur, ut non solum consilia

a remarkable Fact preserved to us by Æthicus in the Preface to his Cosmographia. We are there informed, that Julius Cæsar ordered *a general Survey to be made of the whole Roman Empire* by a Decree of the Senate; the Surveyors are said to have been Men of great Wisdom, and instructed in every Branch of Philosophy. The three Surveyors were Zenodoxus, Theodotus, and Polyclitus, and were each of them appointed to survey a different Division of the Empire. It began in the Consulship of Julius Cæsar and Marc Antony (before Christ 44), and continued for 25 Years one Month and ten Days, to the Con-

consilia mentis, verum ad spectu oculorum, viam profecturis, eligerent. Vegetius De Re Militari, lib. 3. cap. 6.

E — Consulship

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fulship of Sentius Saturninus and Lucretius Cinna (before Christ 19). The Eastern Part of the Empire was assigned to Zenodorus, who finished it in 14 Years five Months and nine Days, being in the Consulship of Augustus IV. and Crassus (before Christ 30). The Northern Part was completed by Theodotus in 20 Years eight Months and ten Days, in the Consulship of Augustus X. (and Flaccus) (before Christ 24). And the Southern Part was finished by Polyclitus in 25 Years one Month and ten Days*.

As

* Itaque Julius Cæsar, bissextilis rationis Inventor, divinis humanisque rebus singulariter instructus, cum consulatus sui fasces erigeret, ex Senatus-consulto censuit omnem orbem jam
Romani

As the different Spaces of Time taken up in each Survey are registered

Romani nominis admetiri per prudentissimos viros & omni Philosophiæ munere decoratos. Ergo a Julio Cæsare & M. Antonio Coss. orbis terrarum metiri cæpit, id est, a consulatu superscripti usque ad consulatum Augusti *tertium* (lege *quartum*) & Crassi, annis xxi. (lege xiv.) mensibus v. diebus ix. Zenodoxo omnis oriens dimensus est, sicut inferius demonstratur. A Consulatu item Julii Cæsaris & M. Antonii usque in Consulatum Augusti decimum, annis xxix. (lege xx.) mensibus viii. diebus x. a Theodoto septentrionalis pars dimensa est, ut evidenter ostenditur. A Consulatu similiter Julii Cæsaris usque in Consulatum Saturni & Cinnæ a Polyclito meridiana pars dimensa est, annis xxxii. (lege xxv.) mense i. diebus x. sicut definita monstratur. Ac sic omnis orbis terræ intra annos xxxii. (lege xxv.) a dimensoribus peragratus est, & de omni ejus continentia perlatum est ad Senatum. Æthici Cosmographia, p. 107. Ed. H. Stephani, 1577.

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according to the Consulships, I have corrected the Numbers in the Manner done by Wesselingus in his Preface to the Itinerary of Antoninus, which indeed is so directly pointed out by the *Fasti Consulares*, that there can be no Doubt of the true Reading. The only Difficulty with regard to the Authenticity of the Fact, arises from the Silence of Pliny, who has made no Mention of these three Surveyors, and of the important Task they had executed, which one should have expected in a Roman Author who otherwise so minutely mentions the Distances taken by the Surveyors of Alexander upon a less interesting Tract of Country. But perhaps we ought to suppose that this was the *general Survey ascribed to Marcus Vip-
sanius*

Janius Agrippa, who was Prime Minister and Son-in-law to Augustus, and which is so often quoted by Pliny, as a Mensuration of great Authority; and as this was a Business too large to be executed by him in Person, it is not unlikely that it was performed by three such Surveyors under his Countenance and Protection; and indeed the Period of Time seems to point out and confirm this Hypothesis: For this Survey was begun in the Year 44. before Christ, in which Julius Cæsar was killed in the Senate House; and as his Power was soon after devolved upon Augustus, therefore the Execution of this Survey, as one of the Plans of his Uncle Julius Cæsar, was in a manner bequeathed to the Nephew, and must have be-

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come a proper Object of the Attention of his Ministers. It was finished likewise in the Year 19 before Christ, when Agrippa was in the Plenitude of his ministerial Power, and just five Years before his Death.

The Roman Itineraries that are still extant, show evidently with what Accuracy their Surveys were made in every Province; and *Pliny* has filled the Third, Fourth, and Fifth Books of his Natural History with the Geographical Distances that were thus measured. We have likewise one ancient Set of Maps still preserved to us, known by the Name of *the Peutingerian Tables*, published by Welfer and Bertius, which give us a sufficient Specimen of what Vegetius calls

calls the *Itinera Picta*, for the clearer Direction of the March of their Armies.

The Roman Empire had been enlarged to its greatest Extent, and all its Provinces well known and surveyed, when Ptolemy, in the Days of Antoninus Pius, about 150 Years after Christ, composed his System of Geography, which has been happily preserved to us amidst the general Wreck that consumed so many other Books of Science. The Materials then extant, and in his Possession, for the completing of that great Work, consisted of various Particulars, some of greater and others of a less Degree of Authenticity. The Principal were the *Proportions of the*

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Gnomon to its Shadow, taken by different Astronomers at the Times of the Equinoxes and Solstices; *Calculations* founded upon the Length of the longest Days; *the Measures* or computed Distances of the principal Roads contained in their Surveys and Itineraries, and the various *Reports of Travellers and Navigators*, who often determined the Intervals of Places by *Hearsay* and *Guess-work*. All of these were to be compared together, and digested into one uniform Body or System, and after this were converted and translated by him into a new mathematical Language, expressing their different Degrees and Minutes of Latitude and Longitude, according to the Invention of *Hipparchus*, but which *Ptolemy* had the Merit

Merit of carrying into full Practice and Execution, after it had been neglected for upwards of 250 Years.

For I believe no Author has ever supposed that Ptolemy had in his Possession real astronomical Observations sufficient to determine all the Longitudes and Latitudes he has given; so that we must always remember, that their degree of Accuracy depended upon the Veracity of the Fact or Suggestion communicated to him, from which they were afterwards deduced. Agreeable to this Idea, we find that Regiomontanus, in his Commentary upon Ptolemy's Geography, quoted by Gefner, though never published, endeavoured to explain an Instrument called *Meteoroscopium*, by which

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he supposes Ptolemy reduced and brought forth the Numbers of his Geography *.

We must not therefore be astonished at the Multitude of Errors to be found there, when his original Materials were so imperfect for executing so large a Work as the fixing the Longitudes and Latitudes of all the Places, Coasts, Bays and Rivers of the then known World; an Undertaking which, even in our Days, has not hitherto been

* *Commentaria in Cosmographiam Ptolemæi, ubi exponitur fabrica usufque Instrumenti Meteoroscopii, quo Ptolemæus ipse universos ferme numeros totius operis sui elicuit: falso enim quispiam crediderit, tot longitudinum latitudinumque numeros per supernorum observationes innotuisse. Gesneri Bibliotheca, p. 439.*

brought

brought to any sufficient Degree of Accuracy.

It was almost impossible for him not to have committed many Mistakes in the Places beyond the Extremities of the Roman Empire, which were indeed out of the Range both of Astronomers and Surveyors. So that those learned Writers who have so sharply criticised some few of his Errors in these Particulars, have not treated him with that Candour which a Work of this Nature deserved. For his Mistakes arose from the Ignorance of the Age in which he lived, which could give him no better Information, and were not properly the personal Ignorance of the Author. And this is a Remark which ought to have its

due Weight in restraining the Wantonness of Criticism in a thousand Instances. *Ricciolus*, *Cellarius*, *Paul Merula*, and *Salmasius*, have all of them * committed this Mistake in their Censures of his Geography, as if they were disappointed in not seeing this Science in its full Maturity in the Writings of Ptolemy, at a Time when it was evidently but just beginning to advance beyond the Verge of its earliest Infancy. They might with equal Justice condemn the modern

* Riccioli Geogr. Præf. Cellarii Notitia Orbis Antiqui Præf. Paul Merula in Præf. Geogr. Salmasius in Solinum, p. 1186. etiam Gherardus Mercator in Præf. Ptolemæi Geogr. Philip Cluverius in Geographia. Velferus in Rerum Augustanarum Libris. See Fabricii Biblioth. Græc. vol. 3. p. 414.

Geographers

Geographers for giving no better Account of Nova Zembla, or New Holland, or of those Continents and Islands that lie on the Northern or Southern Extremities of the Great South Sea towards the two Poles.

If the Observations from which Ptolemy compiled his Geography had been as faithful and accurate as the Principles upon which it was digested were certain, then this Science would have advanced much sooner towards its full Maturity. But when Premises are admitted to be true, which are either doubtful or false, then the Conclusions drawn from them must always be erroneous. Now the principal Mistakes in Ptolemy took their Rise from certain astronomical Observations
and

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and Surveys which were supposed to have been made with Accuracy in an Age prior even to Ptolemy himself; and as that great Author received and adopted them as genuine, having none more authentick by which their Accuracy might have been tried, and having otherwise no reason to suspect them; so succeeding Geographers, for want of better Information, were induced to copy and insert them in their Maps, as being, in their Opinion, of acknowledged and undoubted Authority. And thus Error, when it has once assumed the counterfeit Stamp of Truth by the hasty and unguarded Concession of some eminent Writer, often preserves its Currency during an amazing Length of Time. For these capital Mistakes
kept

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kept their Place in all Maps whatever, by a Sort of unquestioned Prescription, down even to the Beginning of the present Century.

Neither were these Errors such as were introduced in the more distant Extremities of his Maps, which are generally less visited and more uncertain; but they were in the very Center of that Part of the World which was the best known to the ancient Greeks and Romans. For whoever is the least conversant in their History, must know that the Coasts of the Mediterranean were the classic Ground of all Antiquity; War and Commerce occasioned its being incessantly traversed by the Ships of all the contiguous Nations; several great Empires

pires had their Capitals upon its Shores, or at a few Miles Distance; and almost all the ancient practical Astronomers made their Observations in its Neighbourhood.

I shall mention at present only *three* Instances of those Errors, the Consequences of which I shall explain afterwards at greater length.

The *first* is that of *Byzantium*, which, according to Ptolemy, is in the Latitude

of — — — — — $43^{\circ} 5'$ *

But by the best modern Observations is only — $41^{\circ} 1'$

Error in Ptolemy is -- $2^{\circ} 4'$
equal

* In all the Editions of Ptolemy they by Mistake make it $43^{\circ} 6'$ in the Latin Column, when

equal to 124 geographical Miles, or allowing 69 English measured Miles to a Degree, it will amount to 142 measured Miles. This Mistake in Ptolemy was occasioned by the following Passage in Strabo, lib. 2. p. 134.

Ἐν δὲ τοῖς περὶ τὸ Βυζάντιον, ἡ μεγίστη ἡμερὰ ὥρῶν ἐστὶν ἰσημερινῶν δεκαπέντε καὶ τέλειρα, ὃ δὲ γνωμῶν πρὸς τὴν σκιὰν λόγον ἔχει ἐν τῇ θερινῇ τροπῇ ὅν τὰ ἑκατὸν ἑικοσι πρὸς τεσσαράκοντα δύο, λείπεται πέμπτω.

“ That at Byzantium the longest
 “ Day was fifteen equinoctial Hours
 “ and a Quarter, and that the Pro-
 “ portion of the Gnomon to its Sha-
 “ dow at the Summer Solstice was
 “ as 120 to 42 wanting one Fifth, or
 “ in other Figures as 120 to $41\frac{4}{5}$.”

when the Greek Figures are $\mu\gamma. \beta.$ which are $43\frac{1}{2} = 43^{\circ} 5'$.

Strabo

Strabo * has mentioned in four other Passages of his Geography, that the same Proportion as at Byzantium was found at Marseilles by Pytheas, and was taken notice of as such both by Eratosthenes and Hipparchus.

As the Trigonometry made use of by Ptolemy was less accurate than at present, he had therefore determined, from the above Particulars in a grosser Manner, the Latitudes of Byzantium and Marseilles to be $43^{\circ} 5'$; whereas by a more accurate Trigonometry, according to the Length of the longest Day of fifteen Hours and a Quarter, without correcting it from Refraction

* Strabo, lib. 1. p. 63. lib. 2. p. 71. p. 106. & p. 115.

and

and Parallax, and supposing, with Ptolemy, that the Sun's Declination at that time was $23^{\circ} 51' 20''$; his Conclusion ought to have been, that the Latitude was $43^{\circ} 1' 24''$; and if that was calculated by the second Method of the Proportion of the Gnomon to the Shadow of 120 to $41\frac{1}{3}$, and admitting the same Declination, it would be $43^{\circ} 3' 38''$. From both of which it clearly appears, that Ptolemy was in this Particular misled by Hipparchus, who is mentioned by Strabo as having visited Byzantium, and made this very Observation in Person*. It is the more surprizing how this accurate Astronomer should have made so gross

* "Οι γὰρ λόγοι εἶρηκε τῷ ἐν Μασσαλίᾳ γνῶμονι πρὸς τῷ σκιᾷ, τὸν αὐτὸν καὶ Ἰππαρχὸς κατὰ τοὺς αὐτῶν καιρὸν εὗρεν ἐν τῷ Βυζαντίῳ φησιν. Strabo, lib. 1. p. 63.

a Mistake,

a Mistake, when we recollect the Character given him by Ptolemy, Ἰππάρχῳ ἀνδρὶ φιλοπόνῳ τέ ὁμοῦ, καὶ φιλαλήθει, *a Lover of Labour and a Lover of Truth* *; and in another Passage he distinguishes him by the Epithet of φιλαληθείσσιον, *a Lover of Truth in the superlative Degree* †; which he was well justified in giving him, from a Number of Instances of his great Veracity and Candour which he has adduced in the Course of that Work.

The Latitude of Marseilles, which was supposed to be under the same Parallel with Byzantium, was not however so much mistaken, as by the best modern Observations it is found to be $43^{\circ} 17' 45''$. And as in the

* Ptolemy, Almag. p. 59.

† Almag. p. 210.

above Calculation there is a Doubt * whether the Sun's Semidiameter was subtracted from the Altitude, as the Line which bounded the Shadow must have come from the upper Limb of the Sun, therefore we must add $15' 47''$, the Sun's Semidiameter at the Summer Solstice, to $43^{\circ} 3' 38''$, which will make the Latitude of Marseilles to be $43^{\circ} 19' 25''$, which is only a Difference of $1' 40''$, from the latest that has been found by the best-Instruments of Observation.

If we should invert this Calculation, we shall find what was the Sun's greatest Declination in the Days of Pythæas, about 300 Years before the Christian Æra, by admitting the Latitude of Marseilles to be $43^{\circ} 17'$

* Gassendi Opera, Tom. 4. p. 527.

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45'', and the Sun's greatest Altitude according to the Proportion of 120 to 14 $\frac{1}{2}$, to be — — 70° 47' 42'' 15'''

Subtracting the Sun's Semidiameter at the Summer Solstice —

15' 47''

The Sun's Altitude corrected —

70° 31' 55'' 15'''

The Sun's Zenith Distance —

19° 28' 4'' 45'''

Which being deducted from the Latitude

43° 17' 45'''

Gives the Sun's greatest Declination in the

Days of Pytheas —

23° 49' 40'' 15'''

The mean Obliquity of the Ecliptic, or greatest Declination at present in the Beginning of the Year 1768 —

23° 28' 10''

The Diminution of the Declination in 2068

Years is therefore —

21' 30'' 15'''

which is nearly at the Rate of 62'' 23''' every hundred Years.

But

But if we should determine the Rate of this Diminution from a more accurate Observation made by *Albategni* about the Year 880, when he found the Obliquity of the Ecliptic to be $23^{\circ} 35'$, to which if $40''$ is added for the Refraction after deducting the Parallax *, neither of which were at that Time attended to or known, then the Obliquity of the Ecliptic in his Time will stand — — — $23^{\circ} 35' 40''$

The mean Obliquity at present — — — $23^{\circ} 28' 10''$

The Diminution in 888

Years, being from 880 to

1768 — — — $7' 30''$

which is nearly at the Rate of $50''$ in every 100 Years, or half a Second each Year.

The mentioning this Observation of Pytheas at Marseilles, makes it necessary to explain here a little more

* M. de la Lande's *Astronomie*, § 2179. p. 1027.

fully

fully this Question of *the Variation of the Sun's Declination*, which was a Subject much controverted by some of the greatest Astronomers of the last two Centuries, as well as at the Beginning of the present. And it is an additional Reason for entering more particularly into this Detail, because all Observations of Latitude in different Ages taken from the Sun's Altitude, require to be illustrated by a previous Knowledge of the State of this Question.

I shall therefore first give a View of the Observations made by Astronomers in different Ages of the Sun's greatest Declination, as they are collected by *Ricciolus* in his *Almagest*, Vol. i. p. 162, and I shall add the

Continuation

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Continuation of it from M. *De la Lande's*
Astronomie, p. 1028, down to the pre-
 sent Year.

ASTRONOMERS.

	Y. bef. C.	D.	M.	S.
Pytheas of Marfeilles, as above — — —	300	23	49	40 15
Aristarchus of Samos, in the 50th Year of the 1st Calippic Period	280	24	0	0
The Indians quoted by Messahala, cap. 1. part 2. Astrolabii —		24	0	0
Eratoſthenes of Cyrene	230	23	51	20
Hipparchus of Rhodes	140	23	51	20
	Aft. Ch.			
Ptolemy of Pelufium, Almageſt. lib. 1. p. 17 & 18. —	140	23	51	20
Almamon, Caliph of the Saracens, according to Alfraganus —	830	23	35	0
Albategni of Araçta De Scient. Stell. cap. 4. p. 14. Ed. 1645. —	880	23	35	0
	F Arzachel			

ASTRONOMERS.

	Y. of C.	D.	M.	S.
Arzachel of Toledo —	1070	23	34	0
Almazon the Son of Al-				
manfor the Arabian	1140	23	33	30
Thebit Ben Corah —	1210	}	23	33 30
according to others	1287			
Prophatius the Jew —	1300	23	32	0
Purbachius and Regio-				
montanus —	1462	23	28	0
but by their Obser-				
vations being cor-				
rected — —		23	30	0
Petrus Nonius —	1500	23	30	0
Dominicus Maria —	1500	23	29	0
Jo. Vernerus —	1510	23	28	30
Nicolaus Copernicus	1525	23	28	24
but being corrected by				
Ricciolus —		23	30	47
Petrus Apianus —	1530	23	30	0
Orontius Finæus —	1555	23	30	0
Egnatius Dantes —	1570	23	29	0
but being corrected		23	30	30
Astronomers under the				
Landgrave of Hesse				
Cassel — —	1570	23	31	0
		Jo. Homelius		

ASTRONOMERS.

	Y. of C.	D.	M.	S.
Jo. Homelius at Leipfick	1570	23	29	30
Tycho Brahe —	1586	23	31	30
but from some other of his	1586	23	30	36
select Observations with	1587	23	29	30
the Corrections of Ric-	1589	23	30	45
ciolus	1593	23	30	0

N. B. Tycho was the first
Astronomer who made Al-
lowances for the Errors in
Observation from Refrac-
tion.

Philip Lansberg —	1589	23	30	10
but corrected by Riccio-				
lus — — —		23	29	30
Clavius, Scheinerus & Gali-				
leo — — —	1600	23	30	0
Vendelinus according to his				
own Parallax ———	1620	23	30	15
but according to that of				
Ricciolus ———		23	30	30
Peter Gaffendi ———	1630	23	31	0
Ricciolus ———	1643	23	30	0
Bullialdus ———	1645	23	32	0

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ASTRONOMERS.

	Y. of C.	D.	M.	S.
Cassini by the Gnomon in the Church of St. Petro- nius at Bologna —	1655	23	29	0
M. Richer at Cayenne, ac- cording to Cassini —	1672	23	28	54
Mr. Flamsteed —	1689	23	28	56
M. Bianchini —	1703	23	28	35
M. Horrebow —	1709	23	28	47
M. De Louville. Memoires del'Academie 1714, p. 88.	1714	23	28	41
The same from Observations at Marfeilles. Memoires de l'Academie, 1716, p. 59. — —	1716	23	28	24
M. De la Condamine at Quito — —	1736	23	28	24
Dr. Bradley and M. De la Caille — —	1750	23	28	19
Mr. Maskelyne, January 1st	1768	23	28	10

From the Uniformity of the above
Table it is evident, after making all
reasonable

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reasonable Allowances for the Coarseness of the Instruments of the earlier Astronomers, that we cannot deny the Diminution of the Obliquity of the Ecliptic, without doing Violence to the Observations of all the past Ages.

And yet this Position in Astronomy hath had a various Fluctuation of Opinion concerning it, having been adopted by some great Astronomers, and afterwards rejected and exploded by others of equal Abilities and Reputation, till at last, Time, which is the great Touchstone of Truth, by the Assistance of better Instruments of Observation, has at last established it beyond the Power of Contradiction.

Thebit Ben Corah, the Arabian Astronomer, who, according to some, flourished in the IXth, and according to others, in the End of the XIIth Century, was the first who asserted *the Variation of the Sun's Declination* under the Name of *the Motion of Trepidation*.

This Opinion was resumed upon the Revival of Astronomy in Europe by *Purbachius* and *Regiomontanus*, *Copernicus*, *Tycho*, *Lansberg*, *Longomontanus*, *Kepler*, *Vendelinus*, and many others. Some of those Writers considered this apparent Change of Declination to be owing to a small *periodical Vibration of the Axis of the Earth*; and being over desirous of completing an Hypothesis before there

there were sufficient Data, they went even so far as to determine the *Maximum* and the *Minimum* of this Vibration, pretending to fix the very Year when it changed its Direction and began to increase. And as it is too common for many ingenious Men to make all their Knowledge to assume the Form of a System, which is the great Bane of Science, they endeavoured to calculate and apply these critical Periods to the Creation and Birth of our Saviour, with which it is now clear and evident that they have no Connexion.

The opposite Opinion that the Obliquity of the Ecliptick had been invariably the same in all Ages, was maintained by *Gassendi*, *Kircher*, and

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Ricciolus, who endeavoured to explain away the Appearances of Variation, from the imperfect Manner in which the Ancients observed, and from the Contradiction and Inconsistency in many modern Observations, of which indeed the Examples were too frequent. And they were the more inclined to this Idea of no Variation, whatever, foreseeing that a gradual Diminution of Declination would introduce a new Principle of Corruption into the very Stamina of all astronomical Tables. For there must be new Calculations made from time to time of oblique Ascensions, the Latitudes of the Planets and fixed Stars, the Semidiurnal Arcs, and the very Motion of the Sun himself deduced from Declination, besides the
infinite

infinite Number of Problems which depend upon Latitude. They therefore concluded it much more probable to suppose "God Almighty to have WILLED that there should be for ever *one and the same Royal Highway*, namely, the Ecliptick, through which the Sun should appear to make his invariable Path, and which should be the constant Line and Boundary for determining the Latitudes of all the Planets *."

These and other Reasons made so general an Impression on the Astronomers of the last Century, that this Idea, *of there being no Change whatever in the Obliquity of the Ecliptick,*

* Riccioli Almagest. Vol. 1. p. 164.

became the prevailing Opinion in Astronomy for upwards of fifty Years; with this difference however, that $23^{\circ} 30'$ was supposed to be *the invvariable Declination*, according to Ricciolus and others; whereas Messieurs *Flamsteed**, *De la Hire* and *Cassini*, who were the great practical Astronomers at the Beginning of the present Century, lowered their Station one Minute; and adopted that of $23^{\circ} 29'$.

M. *De Louville* once more revived the Theory of *the Variation of the Obliquity*, in two ingenious Papers published in the *Memoires de l'Academie*

* *Flamsteedii Historia Cœlestis*, Vol. 3. Prolegom. p. 124.

des Sciences for 1714 and 1716, where M. de Fontenelle, in giving his Account of the last of these, has the following Observation: "*Malgré toutes les raisons de M. de Louville, les autres Astronomes de l'Academie sont demeurés attachés à l'Obliquité constante de l'Ecliptique de $23^{\circ} 29'$ **" And agreeable to this there is a Paper published by M. De la Hire in the Memoirs of the same Year, 1716, in defence of his own Opinion and that of the rest of the Academy:

But the more ancient Doctrine of *the Diminution of the Obliquity of the Ecliptick*, was at last completely re-established by the accurate Obser-

* Memoires de l'Academie R. des Sciences pour 1716, p. 64. 8vo.

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vations of Dr. *Bradley*, published in the Philosophical Transactions of 1737, where he not only clearly proves the uniform lessening of the Declination, but has discovered a small periodical Variation of 18" in this Diminution, increasing and lessening its Quantity by turns, according to the Revolution of the Nodes of the Moon which is called *the Nutation of the Earth's Axis*.

Bullialdus, in his *Astronomia Philolaica*, published in the Middle of the last Century, when he acknowledges the Variation of the Declination, has added his Opinion, "that it was impossible to investigate thoroughly the physical Cause of this Motion; we know, says he, the Reality of the

“ the Fact, but are ignorant of the
 “ Principle; neither can the utmost
 “ Force of human Genius discover
 “ these Causes *.”

But M. Euler, not intimidated with
 this *Diffum*, and justly confidering,
that every Effect uniformly produced must
have a physical Cause, has applied with
 great Propriety the Neutonian System
 of Gravitation to the Solution of this
 Difficulty, by shewing that the Attrac-
 tion of the different Planets upon the

* *Causam porro illius motus physicam inves-
 tigare penitus impossibile est, scimus rem esse,
 sed causam illius ignoramus, nec potest humani
 ingenii acumen pervidere causas illas. Bulli-
 aldi Astronomia Philolaica, lib. 5. cap. 5.
 p. 229.*

Earth.

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Earth ought to produce this Effect*, and that too in the very Proportion in which it appears in Nature.

This Digression concerning the Obliquity of the Ecliptick, took its Rise from the Observation of the Proportion of the Gnomon to its Shadow, recorded in Strabo, from which Ptolemy was led into an Error with regard to the Latitude of Byzantium, to which I shall now return.

* M. Euler's Paper is in Tom X. of the *Mémoires de Berlin sur les Inégalités de Saturne*, p. 79. See likewise two Papers of M. De la Lande dans les *Mémoires de l'Académie de Sciences pour 1758 & 1761*. And his *Astronomie*, § 2186, &c. p. 1029, &c.

The

The *Arabians*, who copied after Ptolemy's Geography, instead of correcting this Error of the Latitude of Byzantium, increased it to double the Quantity, as if they had been acquainted in general that there was a Mistake of two Degrees without being told on which Side, and therefore they unfortunately added the two Degrees to the 43° given by Ptolemy, instead of subtracting them; for all their Geographers * make the Latitude of Byzantium or Constantinople 45° instead of 41° ; which was an Er-

* Abulfeda, Nassar Eddin, Ulug Beg, *Binae Tabulae Geogr. editæ a Jo. Gravio 1652.* See likewise J. Greaves's Letter to Archbishop Usher, published in the *Philosophical Transactions*, N^o 178, for December 1685.

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ror of four Degrees, amounting to no less than 240 Geographical Miles, or to 276 British measured Miles.

It is surprising that the true Latitude of Constantinople was so grossly mistaken, and continued unknown for so long a Time, though it was the Metropolis of the eastern Empire, and afterwards of that of the Turks. For Amurath III. who was a Cotemporary of Queen Elizabeth, having begun his Reign in 1574, and died in 1595, appears from two Letters of Vendelinus to Gassendi *, to have been the first who took the proper

* Gassendi Opera, Tom. VI. p. 427. & p. 511.

Steps.

Steps to have it known. The Astronomers employed by him having found that in that Part of the City called Topchana, its Latitude was $41^{\circ} 30'$, and its Longitude $56^{\circ} 47'$. Haga, the Dutch Envoy, who gave Vendelinus this Account dated from Constantinople 30th April 1633, adds, that all the Arabian Mathematicians there, were of the same Opinion; though he mentions at the same time, that there were no Astrolabs in that City fit for making an Observation. Vendelinus, who still had greater Faith in the Observation as given by Hipparchus, adds the following Words: *Vix bilem tenebis scio, vix risum, Mi Gassende, ubi hæc leges, ego scio Byzantii.*
Latitudinem.

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Latitudinem Peræ inveniendam 43 grad. 20 min. Serralii proin ac veteris Byzantii 43 grad. 19 min. si verum est Hipparchum invenisse illic eandem ambrem solstitialem quam Pytheas Massiliæ.

This Observation under *Amurath III.* had still an Error of making the Latitude of Constantinople betwixt twenty and thirty Minutes too much, as was found by *John Greaves* in 1638, who, being sent into the East by Archbishop *Laud* for the Purpose of purchasing oriental Manuscripts, found the Latitude there to be $41^{\circ} 6'$ by means of a Brass Quadrant of four Foot Radius *; it has been since more

* Philosophical Transactions for December 1685, and Greaves' Works, Vol. II. p. 364.

accurately

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accurately observed by M. *Cbazellos* *

in 1694, and found to be $41^{\circ} 1' 0''$

By M. Condamine in

1731. — $41^{\circ} 0' 0''$

Upon the opposite Shores

of the Mediterranean,

though much more

westerly, stood *ancient*

Carthage.

Ptolemy has placed it in

the Latitude of — $32^{\circ} 20' 0''$

But its Latitude, accord-

ing to the best Obser-

vations, is — $36^{\circ} 52' 0''$

Error in Ptolemy — $4^{\circ} 32' 0''$

equal to 272 geographical Miles, or

313 British measured Miles.

* Mémoires de l'Académie des Sciences pour 1721, p. 75. and pour 1732, p. 404. 22mo.

This

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This, which is the *second Error*, appears to have been founded upon the following Passage in Strabo, lib. 2. p. 133. Ἐν Καρχηδόνι ὁ γνῶμων λόγον ἔχει πρὸς τὴν ἰσημερινὴν σκιὰν ὅν ἔχει τὰ ἑνδεκά πρὸς τὰ ἑπτα. *In Carthage the Gnomon has the same Proportion to the Equinoctial Shadow which 11 has to 7.* Now by plain Trigonometry this Proportion must give us the Latitude of $32^{\circ} 28'$, which being so near the Latitude adopted by Ptolemy, is a strong Presumption that his Latitude was copied or translated from the Observation as related by Strabo.

Such was the Ignorance of the World in Matters of Geography, that this remarkable Mistake which affected the whole Coast of Africa, from the
Straits

Straits of Gibraltar to the Cape of Mercury, now called Cape Bona, stood unnoticed till the Beginning of the last Century, when Snellius, in a Letter to Gassendi dated July 20th 1625, says, that by Gassendi's Observations he had discovered an Error in Ptolemy's Latitude of Carthage of three Degrees. Atque adeo Ptolemæum quoque in Latitudine Carthaginis Hipponis Regiæ facile tribus gradibus aberrare. Id clarissimè vestræ Observationes coarguunt, pro quibus Geographiæ totius nomine, vobis & vestræ diligentiae gratulor, earum enim ex-pers secundum Ptolemæum pronunciâssem.*

See likewise a Paper of M. Delisle in the Mémoires de l'Académie des Sciences pour 1714, p. 236. 12mo.

* Gassendi Opera, Tom. VI. p. 393.

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The Length of the Mediterranean is the Third capital Mistake in Ptolemy's Geography. It is generally measured from the Straits of Gibraltar to the Bottom of the Bay of Issus, where Alexandretta, or Scanderoon, now stands, whose ancient Name was Alexandria ad Issum, to distinguish it from other Cities of the same Designation.

The Longitude of *Alexandria ad Issum* from the Canaries, or Fortunate Islands, according to Ptolemy * $69^{\circ} 30'$

The Longitude of *Gibraltar*, anciently *Calpe*, or *the Pillar* (viz. of Hercules) *in the Inner Sea*, $\tau\eta\varsigma \epsilon\pi\iota\theta\epsilon\varsigma \theta\alpha\lambda\acute{\alpha}\sigma\sigma\eta\varsigma$, according to the same † — — — $7^{\circ} 30'$

Their difference of Longitude according to him † — — $62^{\circ} 0'$

The difference of Longitude between these two Places according to the latest Observations — $41^{\circ} 28'$

The Error in Ptolemy — $20^{\circ} 32'$

* Ptolem. Geogr. p. 137.

† Ibid. p. 35.

† Snellius, by mistake in his *Eratosthenes Batavus*, lib. 2. p. 232, says, that Ptolemy made it to be nearly $68^{\circ} 30'$, and proposes a Correction of his own, as if it should be $62^{\circ} 31'$.

This

This amazing Mistake which Ptolemy committed in over-rating the Length of the Mediterranean, and which continued in all our Maps more or less till the Beginning of the present Century, took its Rise from the supposed Surveys of different Persons of Reputation recorded by Strabo, several of whom seemed to confirm the Authority of each others Computation, by entering into the smallest Intervals of Distances with an Appearance of Accuracy, and then bringing it nearly to the same Measurement; so imposing is that Concurrence of the various Testimonies of Error, that gives it now and then for a Time the Colour and the Semblance of Truth.

Strabo

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Strabo * says, the greatest Number agreed in allowing that the Distance from the Bay of Iffus to the western Extremities of Spain, was a little less than 30,000 Stadia; and as he mentions that from the Columns to the western Part of Spain, called the Sacred Promontory, now Cape St. Vincent, was a Distance of 3000 Stadia, therefore the Distance from Gibraltar to Iffus was less than 27000 Stadia; in the Detail which he gives afterwards he makes it 26500 and upwards, in the following manner.

	Stadia.
From <i>the Bay of Iffus</i> to <i>Rhodes</i>	5000
From <i>Rhodes</i> to <i>Salmonium</i> , being the eastern Promontory of Crete	1000

* Ομολογῶσι γὰρ οἱ πλείστοι, &c. Strabo, lib. 2. p. 106.

From

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Stadia.

From *Salmonium* to the *Ram's Head*,
 ἐπὶ Κριῦ μετοπον, being the western
 Promontory of Crete — — 2000

in this Distance he says more than
 two thousand, πλείας ἢ δισχίλις.

From thence to *Pachynus*, being the
 South-eastern Promontory of Sicily 4500

From *Pachynus* to the narrow sea,
 ἐπὶ πορθμον, viz. betwixt Sicily and
 Africa, more than a thousand πλείας
 ἢ χίλις — — — — 1000

From the narrow Sea to the Columns
 (viz. of Hercules) or Gibraltar — 13000

26500.

If we reduce these to Degrees of
 Longitude by Ptolemy's * Method of
 allowing 400 Stadia to a Degree of
 Longitude upon the Parallel of 36°,

* Ptolem. Geogr. lib. 1. cap. 11. p. 11.

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it will make the Length of the Mediterranean to be $66^{\circ} 15'$ and upwards, which is only $4^{\circ} 15'$ more than what are given by Marinus whom * Ptolemy strictly adhered to in this Computation.

From <i>Calpe</i> to <i>Caralli</i> in Sardinia, now <i>Cagliari</i>	—	$25^{\circ} 0'$
From <i>Caralli</i> to <i>Lilybæum</i> in Sicily	— — —	$4^{\circ} 30'$
From <i>Lilybæum</i> to <i>Pachynus</i>	—	$3^{\circ} 0'$
From <i>Pachynus</i> to <i>Tænarus</i> in Laconia	— — —	$10^{\circ} 0'$
From <i>Tænarus</i> to <i>Rhodes</i>	—	$8^{\circ} 15'$
From <i>Rhodes</i> to <i>Iffus</i>	—	$11^{\circ} 15'$
		<hr/> $62^{\circ} 0'$

Pliny has likewise given us two Computations of this Distance, one

* Ptolem. Geogr. lib. 1. cap. 12. p. 13.
from

from Polybius, and the other from Agrippa, which I shall first state in his own Words *.

Polybius — ab eodem initio (viz. Gaditano freto) ad Orientem recto cursu Siciliam $\overline{\text{xii}}$ LX mill. ccccc passuum. Cretam cccLxxv. m. pass. Rhodum clxxxvi. m. ccccc. pass. Chelidonias tantundem. Cyprum cccxxv. m. pass. Inde Syriæ Seleuciam Pieriam † cxv. m. passuum. Quæ computatio efficit vicies *ter* (lege *quater* secundum Hardouinum) centena xl. m. passuum. Agrippa hoc idem in-

* Pliny, lib. 6. cap. 33.

† *Pieria Seleucia* was a little to the South of the Bay of Iffus, and being under the same Meridian, they were equally distant from the Straits of Gibraltar.

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tervallum a freto Gaditano ad Sinum
Issicum per longitudinem directam
 xxxiiii. xl. passuum m. taxat, in
 quo haud scio an sit error numeri,—
 hæc est mensura inermium, & pacata
 audacia fortunam provocantium ho-
 minum.

The Numbers of Polybius in the
 Detail, make the Distance amount to
 2448½ Roman Miles; but when he
 sums it up he calls it 2440 Miles,
 according to Hardouin's reading from
 the Chiffletian MS.; for 2340 would
 have contradicted the very Numbers
 he had given. Agrippa computes the
 same Distance to be 3440; but Pliny,
 when he quotes this, adds a Suspicion
 of his own, as if there was an Error
 in the Numbers of Agrippa, *in quo*
haud

hæud scio an sit error numeri; insinuating as if the two Distances were perhaps the same in the two Authors, as the adding one x too much in the Numbers of Agrippa, might occasion the Difference of one thousand Miles in his Computation exceeding that of Polybius, and being really, as I shall make it appear, the Excess above the true Distance.

Let us therefore suppose that Ptolemy had adopted the Numbers of Polybius, and made the Translation or Reduction of them into Degrees and Minutes, we shall find that it would have given him nearly the true Difference of Longitude of the Mediterranean, as it has been since deter-

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mined by the most accurate Observations. For by *Norwood's* Mensuration, in 1635, of the Distance between London and York *, it was found that a Degree on a great Circle of the Earth contained 367196 English Feet, being a little more than $69\frac{1}{2}$ English Miles; and therefore, by the Proportion of the Radius to the Cosine of the Latitude, 297067 Feet will be found equal to a Degree of Longitude upon the Parallel of 36° . But as the Roman and English Foot is nearly equal, and 5000 Feet made a Roman Mile, therefore 73 Roman Miles and

* Dr. Wilson's Dissertation on the Rise of Navigation, prefixed to Mr. Robertson's Elements of Navigation, in two Vols. 2d Edition, 1764.

four Tenths will answer to a Degree on the Equator, and 59 Roman Miles and four Tenths to a Degree of Longitude on the Parallel of thirty six Degrees of Latitude.

Now if we divide 2448.5 by 59.4, it will give us $41^{\circ} 13'$; or if we take it only to be 2440, it will give us $41^{\circ} 4'$ for the Length of the Mediterranean from Gibraltar to the Bay of Iffus, according to Polybius. And as both of these differ very little from the Longitude of $41^{\circ} 28'$, which is found by the best modern Observations, I must confess that this Degree of Exactness and Coincidence of Computation is to me altogether astonishing, and is a new Confirmation

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of the great Accuracy of the Ancients in their Surveys *.

If we next take the Measure given by Agrippa of 3440, in which Pliny suspects there was a Mistake, and divide it in the same manner by 59.4, it will give us $58^{\circ} 20'$ for the Length of the Mediterranean, according to Agrippa: But as the Length given by Strabo amounted, as I have already mentioned, to $66^{\circ} 15'$, therefore Ptolemy seems to have taken a middle Path betwixt these two erroneous Computations of Strabo and Agrippa, when he adopted that of 62° .

* See a Paper of M. Delisle's upon *the Measures of the Ancients* in Matters of Geography, Dans les Mémoires de l'Academie des Sciences pour 1714.

The

The great Misfortune of ancient Geography, and which indeed confined it to such a lingering State of Infancy, was, that the true Method of determining with Accuracy the Difference of Longitudes was a Matter of such Difficulty, and remained so long unknown. It is not therefore so much to be wondered at, that almost all the Longitudes given by Ptolemy are erroneous, and that this remarkable Mistake, in particular, continued undiscovered and uncorrected for many Centuries together.

One of the first Attempts to rectify the Length of the Mediterranean, was made under the Auspices of *Monsieur de Peiresk* in 1635. He was one of the most eminent Men of his Time;

and if we may judge from his Life, wrote by Gassendi, no Person contributed more effectually to the Restoration of Learning upon clear and solid Principles, which began then to be better understood, and to make quicker Advances than it had done in any former Age.

Gassendi informs us *, that M. de Peiresk, with a direct View to the correcting

* Et omnium quidem observata commemorari hæc non possunt; sed taceri tamen non debet, quod pro votis Peireskii fuit, constituisse exinde Tabulas Chartasque Geographicas omnes nimis a nobis abducere illa Ægypti ac Syriæ loca. Quippe cum tribus propè horis, hoc est gradibus quadraginta quinque Aleppum Massilia Orientaliorem constituent; prodiderunt observationes integram penè horam detrahendam

correcting the Errors in the Longitudes of different Places, took particular Pains to get Observations made at Marseilles, Aleppo, and Grand Cairo, of an Eclipse of the Moon which happened in August (viz. the 27th) 1635. Before that Time the Difference of Longitude between Marseilles and Aleppo had been supposed to be 45° , but by these Observations it was found only to amount to 30° ; so that by this a very considerable Correction was made in the Length of the Mediterranean, by cutting off

dam esse, quod inter hæc loca non plures quàm triginta gradus fuerunt numerati. Cassendi Opera, Tom. V. p. 324.

* The real Difference of Longitude has been since found to be $31^{\circ} 58'$.

the Difference of one whole Hour,
or 15° at once.

Geography was at this Time flattered with the Hopes of being soon brought to a fuller State of Perfection than it had ever before attained; for *the Eclipses of the Sun and Moon* were then thought sufficient to determine the Longitudes of all Places with a tolerable Accuracy. But when the ablest Astronomers began to apply themselves to this Branch of practical Knowledge, they soon found that from these Eclipses attended to and observed, as they were with the utmost Care, no clear Deduction could be made of the Longitude of any one Place to any sufficient Degree of Exactness, and the more Observers they

they employed at different Places, they generally by that increased the Multitude of Contradictions and apparent Differences of Estimation.

Ricciolus has collected the Observations of no less than *fifty-six* Eclipses of the Sun and Moon which had happened from 1560 to 1658, all of which had been observed by Men of the first Reputation in Astronomy in that Age; but when they came to be compared, it was then evident, to the great Mortification of Science, that no two Eclipses observed in the same two Places by the same Men, ever exhibited the same Quantity of Longitude. Nay, it was rare if the very same Eclipse did not give a different Longitude according to the
Observation

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Observation of the same Observers, taken from the *four critical Times* in every Lunar Eclipse, which are the BEGINNING, the IMMERSION, the EMERSION, and the END.

It was for these Reasons that several eminent Astronomers, such as Fournier *, Kircher, and even Ricciolus †, gave up the Correction of Geography by the Application of Eclipses of the Sun and Moon alone, as being a fruitless and desperate Undertaking.

Ricciolus has endeavoured to account for the many Inconsistencies that appeared in comparing their Ob-

* Furnerii Hydrograph. lib. 12. cap. 25 & 26.

† Riccioli Geograph. lib. 8. cap. 19. p. 363.
servations

servations arising, as he apprehended, from the following EIGHT different Causes.

1st. Because there was a kind of Smoke or Umbrago which generally darkened the eastern Part of the Moon, before the Disk really entered either the Umbra or the Penumbra of the Earth.

2d. From the Inequalities upon the Disk of the Moon, particularly on the eastern Side, where the Eclipses always begin, and is generally termed *Littus Eclipticum*, the Shore of Eclipses.

3d. From

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3d. From the Penumbra of the Earth varying according to the different Density of the Air.

4th. From the Atmosphere of the Earth, being seldom exactly spherical, arising from the Tumor of the Vapours in different Places, by which neither the Cone of the Umbra or Penumbra would be uniform and perfect, which must affect the Beginnings and Closes of Eclipses.

5th. From a Sort of Atmosphere sometimes observable about the Moon; which had been taken notice of by Mæstlinus in the Eclipse of April 3d 1605, and by Vendelinus at several different Times, which occasioned an
Indistinctness

Indistinctness in the Observation of the Closes of Eclipses.

6th. From the Moon being like the Stones of Bologna, liable to absorb and retain the Rays of the Sun after the direct Rays are intercepted, by which there is a small Appearance of faint Light left upon the Disk; after it is completely immersed in the Shadow of the Earth.

7th. From the Difference in the Eyes of the Observers, which are often quicker or slower in their Observations of the Beginnings and Ends of Eclipses, and which cannot even be remedied by the Assistance of Telescopes.

8th. From

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8th. From the Inaccuracy of many in determining the Times of Eclipses, from the Imperfection of Instruments, and the Use of them in taking the right Ascensions, Azimuths and Altitudes of Stars near the Meridian, or in their Tables of Sines and Logarithms, or in their Calculations from these Tables.

Such were the supposed Causes which made the Astronomers in the Middle of the last Century prefer even common Itineraries and Chorographical Maps to the Eclipses of the Moon, for determining the Longitudes of Places at a small Distance from each other. But when the Intervals were very considerable, they did indeed allow that Eclipses well observed might

might be of great Use; yet still, however, in those greater Distances, they were of Opinion that they should only be admitted under Restrictions; for as Errors of 16' or 20' of Time, equal to 4° or 5° in Space, were often found to occur, it made them resolve never to acquiesce in the Longitude as determined by an Eclipse, unless it was otherwise contained within the probable Distances, examined according to the Chorographical Intervals.

The Length of the Mediterranean was therefore still doubtful and uncertain, and continued a Problem in Geography unresolved during the greatest Part of the last Century, till at length *the Eclipses of the Satellites of Jupiter* were made use of, and found effectual

effectual for that Purpose. They had been first discovered by *Galileo* * on the 7th of January 1610, by means of the Telescopes invented by Metius in Holland in 1608, and the great Advantage that might be derived from them in determining the Longitudes of Places, was conceived very early by that great Astronomer, as appears from his *Nuncius Sidereus*, published in March 1610, which was within two Months of the first discovery †. After twenty Years spent in observing them, he sent a Proposal

* *Tres primum primusque Galilæus, Anno 1610, die 7 Januarii horâ noctis primâ deinde nunquam plures quam quatuor prope Jovem Stellâ detexit. Riccioli Almagest. Vol. L. p. 489.*

† *Gassendi Opera, Vol. V. p. 275.*

to *Philip IV. King of Spain*, in 1631 *, to introduce the Practice of applying them for the Purposes of Navigation and Geography. He afterwards made the same Proposition to the *Dutch* †, who embraced it more readily, being at that Time the great Encouragers of Navigation. In consequence of which they sent *Hortensius* and *Bleaw* ‡, two of their best Astronomers, to Florence, to attend Galileo in his Observations, and to be initiated in all the

* Langrenus initio Selenographiæ.

† Riccioli Geogr. p. 317.

‡ Weidleri Historia Astronomiæ, p. 425. Les Hypotheses & les Tables de Satellites de Jupiter, par Cassini, p. 3. Ed. 1693, dans le Recueil d'Observations pour perfectionner l'Astronomie & la Géographie.

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Calculations necessary for composing the Tables of the Motions, Revolutions and Eclipses of these *Medicean Stars*, which was their Appellation at that Time in Italy. But these Ephemerides were soon interrupted by the Misfortunes which befel Galileo from the Inquisition in 1633, for his having publicly adopted the Copernican System, which they were pleased to condemn as a most dangerous Heresy: And after obliging him to make a solemn Recantation, they first imprisoned him, and afterwards softened it by a Confinement for Life in the Village of Arcetri, where he soon lost his Sight; his many Years Observation of the Satellites having in all Probability brought that Calamity upon him.

The

The Imperfection of the Telescopes of that Age, long retarded the Progress of this Discovery. * Greaves mentions in a Letter dated from Sienna, August 25th 1639, that Galileo never made but two good Glasses, and these were of old Venice Glass. What some others made use of in their Observations, were either so indistinct from the Smallness of their magnifying Power, or from the Inexperience of the Observers, that they often confounded the Satellites with the fixed Stars that were near them. Thus *Antonius Maria Schyrleus de Rheita*, a Capuchin, thought he had discovered at Cologne, on December 29th 1642, five new Satellites round Jupiter, making

* Greaves's Works, Vol. II. p. 480.

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up the number *nine*, which * Gassendi refuted in a Dissertation wrote on purpose, shewing that the Capuchin had converted some of the fixed Stars in the Constellation of Aquarius into Satellites. But notwithstanding this, *Fontana* and *Zupus*, two Astronomers of Naples, persisted in the same Error; *Fontana* pretending to have observed them from 1630 to 1646, when he published his Observations †, mentioning the Days when he has seen sometimes 7, 8 and 9 Satellites, and none of them ever above ten Diameters of Jupiter's Body distant from Jupiter; and he concluded they could

* Gassendi Opera, Tom. IV. p 511.

† Novæ Cœlestium & Terrestrium Rerum Observationes.

not be fixed Stars, because he lengthened the Tube of his Telescope when he looked at these Satellites, whereas he contracted it when he viewed the fixed Stars. *Zupus* went still farther, and asserted in a Letter to Ricciolus, dated February 4th, 1644, that he had seen to the Number of *twelve* Satellites, and sent him a Delineation of their Situations and Distances. And though Reinerus had assured Ricciolus upon this Occasion, that he himself, in ten Years Observations, had never seen but *four*; yet Ricciolus, when he published his *Almagest* in 1651, was so puzzled with these various Accounts, that he would not venture to give an Opinion which of his Friends the Astronomers were in the Right, and therefore chose to

H

pro-

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pronounce upon this Question in the Words of the Roman Prætors when they were at a Loss how to determine a Cause, *Amplius, quia non liquet* *.

. In this State of Uncertainty it was some Time before the Theory of the Secondary Planets came to be regularly reduced into Tables; and though *Simon Marius* first, and after him *Baptista Hodierna*, composed Ephemerides of their Motions, yet nothing of that sort was found to be sufficiently accu-

* Proinde cum veritas nondum manifesta mihi sit, quæ amicitia prævaleat; nolo litem dirimere inter amicos aut ullam de hac re sententiam pronunciare; sed potius cum Romanis Prætoribus ad antiquam me formulam illum redigere, *Amplius, quia non liquet*. Riccioli Almagest. Vol. I. p. 490.

rate

rate for the Purposes of Longitude, till M. *Cassini* published his Tables of the Revolutions and Eclipses of the Satellites in 1668*.

The first Opportunity of effectually applying this Theory to the rectifying of Geography, was suggested by M. *Cassini*, and taken by M. *Picard* in the Years 1671 and 1672, who made a Voyage for that and other Purposes to *Uraniburgb*, the Observatory of *Tycho Brabé*, which was situated in the little Island of *Huena* in Denmark, being in the Entry of the Baltick, betwixt Copenhagen and the Sound. He there observed two Immersions

* Fontenelle's Eloge de M. *Cassini* dans les Mémoires de l'Académie des Sciences pour 1712.

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and three Emerfions of the first Satellite of Jupiter, which were afterwards compared with the fame observed by M. Caffini at the Observatory at Paris. The two Immerfions were on October 25th 1671, and January 4th 1672; the three Emerfions were on March 14th, March 29th, and April 6th 1672. The Mean of all which, compared with thofe of Paris, gave a Difference in Time of $42' 10''$, being equal to $10^{\circ} 32' 30''$ Difference of Longitude. The Telescope ufed at Paris was 18 Feet long, that at Uraniburgh 14 Feet; both of which had nearly the fame magnifying Power.

It was then apparent how ineffectual all the former Methods had proved
for

for determining this Question, as *Kepler*, who preferred the Eclipses of the Sun, had calculated the Difference of Longitude half a Degree too little. *Ricciolus* had made a Mistake of almost a whole Degree too much; and *Bullialdus* and *Longomontanus*, who had observed so many Lunar Eclipses at Paris and Copenhagen, had made a still greater Error of one Degree and a Half*.

I have been the more particular in explaining minutely this first Experiment made by means of the Satellites, because it gave at once the Difference of Longitude in the clearest Manner beyond the Possibility of a

* Voyage d'Uranibourg par M. Picard. p. 28.

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Doubt; and it likewise communicated the certain Prospect of rectifying the whole Extent of Geography as to Longitude, upon Principles that were self-evident, and not liable to any Mistake whatever.

In consequence of this Success, Messieurs Picard and De la Hire, two of the French Academicians, were immediately employed in examining and correcting *the Map of France*; in doing which they were obliged to contract it every where within less Boundaries than it was supposed according to their former Maps to have occupied *, paring off *one Degree* and upwards

* The Outline of the two Maps is published dans le *Récueil d'Observations pour perfectionner l'Astronomie*

upwards of Longitude from the Western Capes of *Bretagne*, and from thence Southward nearly the same Quantity all along the Coast of Poictou, Guienne and Gascogne, to the Bottom of the *Bay of Biscay*, and in like Manner they cut away *half a Degree* from the Shores of *Languedoc* and *Provence*; which gave occasion to Lewis XIV. to tell them in Joke upon their return, *That he found by their Journey he had suffered a Loss of Part of his Kingdom* *.

Other Academicians determined by the same Method the Longitudes of

l'Astronomie & la Geographie, par Messieurs de l'Académie Royale des Sciences. Paris 1693.

* Fontenelle's Eloge de M. De la Hire, dans les Mémoires de l'Académie des Sciences pour 1718.

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the Isle of Gorée, near Cape Verd, on the Coast of Africa, and of Guadaloupe and Martinico in the West Indies *. And as M. Cassini had greatly improved his Tables of the Satellites of Jupiter, and published a new Edition of them in 1693, it was then thought proper to send *M. Chazelles* up the Levant, to observe the Longitudes and Latitudes of Scanderoon, Alexandria and Constantinople, in order to determine the Length and Breadth of the Mediterranean, which he executed with great Ability.

* *Observations Astronomiques*, p. 65. dans le Recueil d'Observations pour perfectionner l'Astronomie & la Geographie.

The Longitude of Alexandretta, or Scanderoon, was found by him to be $34^{\circ} 15'$ East of the Meridian of Paris, from a Transit of the first Satellite of Jupiter over the Body of that Planet, January 14th 1694, from a Conjunction of the first and second Satellite which happened the same Day, and from two Emerfions of the first Satellite which happened on the 22d and the 28th of the same Month; all of which being compared with the same Observations made at Paris by M. Cassini, gave a Difference in Time of two Hours and seventeen Minutes, which being reduced to Space, gave the Longitude as above-mentioned *.

* Mémoires de l'Académie des Sciences pour 1721, p. 75.

The other Part of the Longitude of the Mediterranean, containing that Division of it from the Meridian of Paris to the Straits of Gibraltar, has not hitherto been so accurately determined. M. Deffisse mentions in a *Memoire* * drawn up for the Information of the Duke of Orleans, then Regent of France, "That no astronomical Observations had been made "for ascertaining this Distance prior "to the Year 1720;" he had therefore, by the Assistance of the Sea Charts, made it to be $7^{\circ} 30'$ from the Meridian of Paris to that of Gibraltar, having considered Algiers to be $1^{\circ} 25'$ to the Eastward of that of Paris. But

* Mémoires de l'Académie des Sciences pour 1720, p. 477.

by an Eclipse of the Moon observed at Algiers by the Missionaries of St. Lazare, on August 8th 1729, mentioned by M. De la Condaminé*, it would seem that Algiers was $7^{\circ} 15''$ to the Westward of Paris, which makes a Difference of $1^{\circ} 32' 15''$. So that there will a Doubt still remain with regard to the exact Situation both of Gibraltar and Algiers; and they may therefore be supposed to be included under M. Deffille's Remark †, "That
" there

* Mémoires de l'Académie des Sciences pour 1732, p. 404.

† Il y a dans l'Univers beaucoup de lieux essentiels à la Geographie & à la Navigation, dans lesquels on n'a pas encore fait aucune observation pour en fixer la situation, & nous avons plusieurs autres lieux observés dont les circon-

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“ there are many Places upon the
“ Earth, the Knowledge of whose Si-
“ tuation is essentially necessary for
“ Geography and Navigation, in
“ which there has been no Obser-
“ vation as yet made for that Pur-
“ pose; and there are besides many
“ other Places, which, though they
“ have been observed, yet certain
“ Circumstances attending the Ob-
“ servation have rendered the Deter-
“ mination doubtful.”

Since the Correction of Longitudes
has been introduced by means of the
Satellites of Jupiter, other Methods

stances on rendent la determination douteuse.
Mémoires de l'Académie de Sciences pour 1720.
P. 474.

have

have also been adopted and devised, which are proper and effectual for that Purpose; such as *the Transits of Mercury and Venus* over the Body of the Sun; *Occultations* of the fixed Stars by the Moon: And since *the Lunar Tables* have been improved by M. Mayer, another large Field has been opened equally applicable to this important Object, by measuring from time to time the exact *Distances of the Moon from the Sun, and from a fixed Star* of the first and second Magnitude. Each of which Observations being carefully compared one with another, are like so many new Experiments which must either confirm or contradict the Longitudes that have been already observed. There is one fortunate Circumstance likewise attends all these
various

various Methods, which is, that when they happen to differ in their Conclusion, there is always a *Limitation of Error* pointed out, which gives so far a Degree of Satisfaction, and prepares the Way for bringing the Point that is thus unsettled, to a more speedy and certain Determination.

In explaining the Mistake of Pro-
lamy in his over-rating the Length
of the Mediterranean, by upwards of
one thousand Miles, and in shewing
likewise the Method of its Corre-
ction, I have been gradually induced
to trace the successive Improvements
that have been introduced in taking
the Longitude from that Period down
to the present Times. It will not
therefore be improper to give as a
Counter-

Counterpart some Account of *the Time and Manner of rectifying the Latitudes of different Places.*

Little was done in Geography from the Days of Ptolemy to the Restoration of Learning in Europe, for the Arabian Geographers copied and retailed all his principal Errors. They observed indeed, under their Caliph Almamon, in the Beginning of the IXth Century, a Degree of Latitude on the Plains of Sinjar, or Shinar, near Babylon *, and found it to measure

* Greaves, in his Preface to Abulfeda's geographical Description of Cheraunia, &c. being the Countries beyond the River Oxus, printed, London 1650, at the End of his *Epoche Celebrieres*, has these Words: *Abulfeda alibi refert*

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ture $56\frac{2}{3}$ Arabian Miles, each of which consisted of 4000 Cubits, or 6000 Feet; from which they determined the Circumference of the Earth.

When Science began to be revived in Europe, it was some Time before the Astronomers of that Age were able to obtain Copies of Ptolemy's

refert Aftronomos. juffu. Almamonis in Campis Singar, prope Babylonem, ex Observationibus deprehendisse LVI Milliaria & $\frac{2}{3}$ uni gradui competere. Ricciolus, in his Almageft, Tom. I. p. 61. quotes Alfraganus as faying, that this Mēfuration was made on the Plains of Fingar, adjoining to the Red Sea. Almæon Rex Arabum ut refert Afraganus — convocatis pluribus Sapientibus Geometris juffit vos in Campis Fingar juxta rectum iter Maris Rubri explorare, quot Milliaria infint. uni Gradui Meridiani Circuli, &c.

W

Geography;

Geography; and even then it was with Difficulty they could read and clear the Manuscripts of some of their grossest Errors: For wherever Numbers were inserted in any Author, and made the Bulk of the Composition, the Mistakes were generally multiplied more abundantly in the transcribing; because the Sense did not there, as in most other Books, by a Kind of Self-evidence, assist the Copier in preserving the Authenticity of the Original.

It required likewise some longer Space of Time before the Astronomers constructed proper Instruments, in order to try whether these Latitudes so recorded, corresponded with the Situations as they really stood in Nature.

ture. But when they came actually to observe them, they discovered the Latitude of many Places materially different from what had been set down by Ptolemy; and finding this Variation in some of them to be nearly of the same Quantity, instead of accounting for this Difference from the Imperfection of Instruments, the Inaccuracy of Observers, and the Method of Ptolemy's Conversions, which I have already explained, they hastily concluded that the Axis of the Earth had shifted its Position, by which the Latitudes of all the Places in Europe had been increased. This was the Idea of Dominicus Maria of Ferrara about the Year 1489*, who fancied

* Snellii *Eratosthenes Batavus*, lib. 1. p. 41.

that

that the Variation was at the Rate of one Degree in 1050 Years; so that after a long Revolution of Ages, it would happen that the Countries now under the frigid Zone should be found in the Torrid; and that in like Manner those Regions which suffer from the Violence of the Heat, should gradually pass into the temperate and frigid Zones. Men of warm Imaginations might easily work up this Dream of Geographers into a beautiful and an equitable Disposition of Nature *.

This

* Some of the Geographers among the Ancients had given some Countenance to this singular Notion. Strabo tells us, lib. 2. p. 68. in the Beginning of his Second Book, that Eratosthenes was of Opinion that the Mountains

of

This Hypothesis was again adopted by Maginus of Bologna, about a hun-

of Asia were not then found to lie in the same Situation in which the ancient Maps had placed them, but had shifted towards the North, and that India had been attracted in the same Manner, and was become more northerly than before. Πολὺ γὰρ ἐπὶ τὰς ἀρκτοὺς παραλάττει τὰ ἰσθινὰ μέρη τῶν ὁρῶν κατ' αὐτοῖς, συνεπισπᾶσθαι δὲ καὶ τὴν Ἰνδικὴν ἀρκτικώτερον ἤδη γνομμένην.

Pliny likewise, lib. 36. cap. 10. when he mentions the *Obelisk* which was erected in the *Campus Martius* at Rome, by means of which they determined the Lengths of the Days, and their Variations; subjoins, that the Observations for the last thirty Years did not answer, from some Change in the Heavens, or in the Position of the Earth, and which had been taken notice of in other Places. *Hæc Observatio triginta jam ferè annis non congruit, sive Solis ipse diffusus cursu, & cæli aliqua ratione mutato, sive universa tellure aliquid a centro suo dimota, ut deprehenditur & in aliis locis accipio, &c.*

hundred Years after, towards the Close of the XVIth Century, in which he had the Concurrence of several of the Italian Astronomers. And their Authority made such an Impression upon Tycho Brahé, that being desirous of clearing up a Doubt which he thought had some Foundation, he therefore applied to the Republick of Venice * to send some good Observers into Egypt, to verify whether the Height of the Polé was still the same at Alexandria as it had been found by Ptolemy. For as that City had been formerly as it were *the Metropolis of Astronomy*, there could be no doubt but that the Height of the

* M. Cassini dans les Mémoires de Mathématique & Physique de l'Académie, R. de Sciences de 31 Juillet 1693, p. 116.

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Pole there must have been accurately observed for a long Series of Years by their ablest Astronomers, and that Ptolemy must have examined it himself with his utmost Attention before he had made use of it in his Astronomical Calculations; but Tycho's Request was not then complied with. However, when the Observation was made, it did not sufficiently support their Hypothesis; for Ptolemy having found Alexandria to be $30^{\circ} 58'$ according to his *Almagest* *, or 31° according to his *Geography* †; the Observations made since by Mr.

* Ptolemæi Mathem. Syntax. lib. 5. cap. 13. p. 123.

† Ptolemæi Geogr. lib. 4. p. 103.

Greaves* in 1638, made it amount to $31^{\circ} 10'$, and those by M. Chazelles in 1694, and by M. Condaminé in 1731†, fix it at $31^{\circ} 11'$; which though a Variation of eleven or thirteen Minutes, may be charged, as in many other similar Cases, upon the Errors of Instruments and Observers.

Peter Petit, a Mathematician of some Eminence in France, endeavoured to revive this Opinion in a Dissertation‡ published in 1660, from
the

* Greaves's Works, Vol. II. p. 513. Dr. Birch says in a Note there, that in other Places of the MS. our Author makes it $34^{\circ} 5'$ and $34^{\circ} 3'$.

† Mémoires de l'Académie des Sciences pour 1721, p. 75. & pour 1732, p. 404.

‡ P. Petit in Epistola ad Sauvallum, De Latitudine Parisensi. Cassini dans les Mémoires

the apparent Variations in the Latitude of Paris, as taken by the ablest Astronomers, some of whom had made it $48^{\circ} 39'$, others $48^{\circ} 45'$, sometimes $48^{\circ} 50'$, and at other times $48^{\circ} 55'$. All of which only confirms an Observation made by an eminent French Astronomer, that they had no good Quadrant fit for taking an Observation of the Latitude, even in the whole Kingdom of France, in the Year 1664. For M. Auzot, in a Letter which he addressed to Lewis XIVth in this very Year, made use of the following Words: Mais, Sire, c'est un Malheur, qu'il n'y a pas un Instrument à Paris, ni, que je sçache, dans tout

moires de Mathem. & Physique pour 1693,
P. 117.

voire

voire Royaume, auquel je voulusse m'assurer pour prendre précisément la Hauteur de Pole.*

The Latitude of *London* was known much sooner than that of *Paris*, and brought to a greater Degree of Accuracy; for it was determined by *Edward Wright*, who is otherwise distinguished as the original Inventor of what is called *Mercators Chart*, by Observations made in 1593 and 1594, from the greatest and least Height of the Pole Star, and found to be $51^{\circ} 32' \dagger$, taken by a Brass Qua-

* *Astronomie de M. De la Lande*, Vol. II. p. 842.

† *Horrocii Opera Posthuma*, p. 51, & p. 70.

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drant of six Foot Radius; before that Time the Latitude of London was supposed to be $51^{\circ} 45'$ in all the Maps of that Age. And though this Observation was made at a Time when the Error from Refraction had been just discovered by Tycho, and not fully known, yet it is allowed to be just and exact even now, when the Instruments which are constructed at present enable Observers to come to the utmost Precision of Seconds,

Nothing can be a stronger Proof of the Coarseness of all the Observations, both in Astronomy and Geography, prior to the Days of Tycho, than the Ignorance of Astronomers with regard to the Error arising from *Refraction*; for this occasions a Mistake

at

at the Horizon of no less than $33^{\circ} 45''$, and is found in all the intermediate Altitudes, though gradually lessening, up to the Zenith. When Tycho first discovered it*, by using better Instruments than former Observers, he erroneously supposed that the Sun had no Refraction when he was above *forty-five Degrees high*, and that the Stars had none when their Height was upwards of *twenty Degrees*†; whereas the Refraction is now found, by more accurate Experiments, to be the same in both: And that though this diminishes imperceptibly, yet it never

* Gassendi Opera, Tom. V. p. 423 & 4.

† Tycho likewise supposed that the Sun's Refraction *at the Horizon* was $34'$, but that of the Stars only $30'$.

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vanishes intirely, till they are quite vertical.

It must be allowed, indeed, that some of the Astronomers before his Time had taken notice of it, as altering the apparent Places of the Stars; but they had a very imperfect Idea both of the Principles on which it was founded, and of the Quantity of the Error which it produced. *Roger Bacon*, who flourished in the XIIIth Century, tells us*, “*That the Stars*

* Nam si quis per instrumenta, quibus experimur ea quæ sunt in cœlestibus, cujusmodi vocantur armillæ vel alia, accipiat locum alicujus *Stellæ* circa æquinoctialem in ortu suo, & deinde accipiat locum ejusdem quando venit ad lineam meridiei, inveniet in loco meridiei distare eam sensibilibiter plus a polo mundi septentrionali, quam quando fuit in ortu. *Rogeri Baconis Specula Mathematica*, p. 37.

“ appeared

“ appeared sensibly to be at a greater Distance from the North Pole when they were in the Meridian, than at the Time of their Rising.” In his accounting for it, he distinguishes betwixt the perpendicular and the oblique Rays, and tells us, that *Ptolemy*, Lib. V. *De Opticis*, and *Albazen*, Lib. VIII. were of the same Opinion. But when he endeavours to explain his Ideas more particularly, he introduces his Theory of the Spheres of Air and of Fire, which was the Mode in Philosophy of those dark Ages, and has been long ago exploded.

After Tycho had discovered the Error and the Quantity of Refraction as he imagined, he was then desirous of knowing whether *Copernicus*,

I. 3.

from

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from an Omission of this necessary Deduction, had not been deceived in the true Latitude of *Fruenburgh*, the Place of his Residence, at the Mouth of the Vistula, where it discharges itself into the Baltick; and if so, then he concluded that all his other Observations must be so far erroneous, and require to be corrected by the same Deduction. He therefore sent *Elias*, one of his Scholars, with proper Instruments, thither in 1584, who found that the Latitude of *Fruenburgh* had been really mistaken no less than three Minutes, as it was observed to be $54^{\circ} 22'$ and $\frac{1}{2}$, instead of $54^{\circ} 19'$ and $\frac{1}{2}$, according to Copernicus*. At *Königsberg*

* It is remarkable that Copernicus had made nearly the same Mistake in *the Sun's Declination*,
that

nigſberg likewise, where. *Erasmus Reinholdus* had lived and published his *Tabula Prutenica*, Elias discovered in the same manner that this Astronomer had been misled by Peter Appian, so as to be mistaken twenty six Minutes, which was near half a Degree; for the Latitude of that City was found to be $54^{\circ} 43'$ instead of $54^{\circ} 17'$, which Reinholdus had adopted in his astronomical Tables *.

that he had done in the Latitude of Fruenburgh, being an Error of betwixt two and three Minutes, arising in both Cases from his not making Allowances for the Refraction. Copernicus, in lib. v. Revolutionum, cap. 30. comparing his Situation at Fruenburgh with Alexandria, makes use of the following Words: *Ptolemæo, Alexandriae serenitatem & aëris puritatem plurimum fuisse, cum ipse locum incoletet, sædum nebulis & viftulæ vaporibus præpinguem.*

* Gassendi Opera, Tom. IV. p. 410.

It is somewhat remarkable, that when M. Picard, the French Astronomer, went to Uraniborgh in 1672, he seemed to make *a fair Reprisal* upon Tycho in return for his detecting the Errors in Latitude of Copernicus and Reinholdus. For though Tycho was at infinite Pains in determining the Latitude of Uraniborgh to be either $55^{\circ} 54' 30''$, or $40''$, or $45''$, being in an Uncertainty betwixt these three Numbers *; yet M. Picard, by a Variety of the most accurate Observations, discovered that all of them were too much, and that the least of them had a Mistake of one Quarter of a Minute, as the real Latitude of Uraniborgh was exactly $55^{\circ} 54' 15''$.

* Voyage d'Uranibourg, p. 17.

He found a still greater Error in Tycho's Meridian Line*, amounting to no less than 18' or 20', as the true Meridian was found to be so much to the West of the North of that which results from the Positions given by Tycho.

The French Astronomers seemed to think that their Advantage over Tycho, in these particular Observations, arose from an Improvement made a few Years before, in 1667, by having a small Telescope fitted upon their Quadrants and Sectors instead of the Pinnulæ or Sights, which were in use before that Time; by which means they were enabled to take the Angles

* Voyage d'Uramibourg, p. 11.

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and Altitudes with a superior Degree of Exactness.

But however flattering it was to the Vanity of the French Astronomers to have discovered and corrected the Errors of so eminent an Observer as Tycho, yet we may reckon it as the Happiness of the present Age that so many new Improvements have been made in Instruments of all Sorts since that Time, by which the Progress in Astronomy and Geography has been quickened much beyond the Ideas of our Forefathers. Quadrants and Sectors are now so accurately divided, that the Eye can scarce distinguish so exactly as it is performed by the Instrument; so that in order to *read* the Observation with the Precision
with

with which it is executed; we must take the Assistance of magnifying Glasses, the Divisions of Nonius, and those circular Micrometers where the Revolution of the small Thread of a Skrew is divided into 360, or any other aliquot Parts of a Circle. And if any one Country can claim a Merit in having distinguished itself more eminently than another in these Improvements, it is this Kingdom, where the best Instruments of Observation have been acknowledged to be made for upwards of half a Century.

There is another Particular hitherto unmentioned, which has greatly contributed to the solid Advancement both of Astronomy and Geography, and this is the more accurate Method

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now practised for *the measuring of Time*, which though in appearance of a different Nature, is equally capable of being applied to *the Mensuration of Space*. For in the Tables of Longitude it is well known that Time and Space are used like two different Languages, where the same Truth is expressed with equal Clearness in both, though in Characters that are essentially different from each other; as one Hour in Time is allowed to be equal to fifteen Degrees in Space upon the Surface of the Earth, and of course all the aliquot Parts of each are in the same Proportion.

Sun Dials and *Clepsydrae*, or Water Clocks, were the principal Measures of Time among the Ancients.

It

It was only about the Year of Christ 1300, that *Clocks with indented Wheels* are said to have been first in use. And it was not till 200 Years after this that they seem to have been employed for the Purposes of Astronomy. For Waltherus, the Disciple of Regiomontanus, is said to have had one about the Year 1500; which Schoner, who published his Observations in 1544, says, was so regular, that from Mid-day to Mid-day it perfectly agreed with the Sun, and was almost as exact in the Times given, as in those drawn from Calculation. Tycho Brahé is said to have had four Clocks which marked Minutes and Seconds, the largest of which had only three Wheels; the Diameter of one of them was three Feet.

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Feet, and it had 1200 Teeth*. But all of those were exceedingly imperfect, till Monsieur Huyghens improved them in 1656, by his Invention and Application of *the Pendulum*, whose Vibrations were regular and isochronical. The Improvements that have been since made in *Clocks* and *Time-pieces*, and the Manner in which they have been applied to the Determination of Longitude, is a Branch of Knowledge that will be best learned from the Books which have been professedly wrote upon this Subject.

It was never my Intention in this Dissertation to enter into the Discussion of the present State of Geogra-

* De la Lande's *Astronomie*, p. 917, &c.

phy, or to give the comparative Excellence of the Maps of different Countries. The Field is much too large to be attempted without better Materials and more Leisure than I am now Master of. It has, besides this, been already executed with great Ability and Knowledge by M. *Robert de Vaugondy*, in the Introduction which he has prefixed to his *New Atlas*.

I must, however, observe upon the whole, that Geography is a Science even still many Stages removed from Perfection. The Maps of America, and the Eastern Parts of Asia, though they have been of late two of the great Theatres of War and Commerce, are perhaps more unfinished than any of the rest. Every new Map
that

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that is published of these Countries, seems to blast all those that went before them, and it will require perhaps the Experience of half a Century to come, before a sufficient Number of Observations shall be made to verify the Situations of their most considerable Towns, Coasts and Rivers, so as to approach the Accuracy with which the Maps of the different Kingdoms of Europe are now executed.

And yet upon this Occasion, I must confess, that even the Maps of Great Britain and Ireland are still very imperfect and unsatisfactory; and the Numbers we have of them, varied and re-published without any real Improvements, justly confirm an Observation which Lord Bacon has wisely made

made in a similar Case, "*That the Opinion of Plenty is one of the Causes of Want* *." The late Dr. Bradley was of Opinion, that there were but two Places in England whose Longitude might be depended upon as accurately taken, and that these were *the Observatory at Greenwich*, and *Sherborn Castle*, the Seat of the Earl of Macclesfield in Oxfordshire, and that their Difference was one Degree in Space, or 4' in Time; but even this has been found to be inaccurate by the late Transit of Venus, as being only 3' 47" †. If we should examine the Longitude of *the Lizard*, we shall

* Bacon de Augmentis Scientiarum Prelim. § 4.

† Philosophical Transactions for 1762, vol. lii. p. 624.

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scarce find two Geographers of the same Opinion. In the Account of Longitudes prefixed to Halley's Tables, it is said to be $4^{\circ} 45'$ from the Observatory, which is therefore $4^{\circ} 40'$ from London; according to others it is 5° and $3^{\circ} 5'$, and by some $5^{\circ} 14'$ *, and by others it is enlarged even to 6° ; this surely is a Matter worthy the publick Attention, when we consider that it is a Point of Land the most important of all others to the Navigation of this Kingdom †.

* Robertson's Navigation, vol. i. p. 378.

† This is held to be so uncertain, that Sailors when they approach the Mouth of the Channel, generally think it safest to *gripe* their way by Soundings, rather than depend upon Observation or Calculation.

I shall

I shall therefore conclude this Dissertation with observing, that all Maps in general ought to be considered as *unfinished Works*, where there will be always found many things to be corrected and added, and that they ought to have a Kind of *floating Title* affixed to them, expressive of their imperfect State, similar to what Pliny tells us was practised by the greatest Painters and Statuaries of Antiquity; such as, *Apelles faciebat aut Polycletus*, but not *fecit*; claiming an Indulgence to the Artist, as if he was employed to his last Moments in correcting the Faults of his Composition, *tanquam inchoata semper arte & imperfecta, ut contra judiciorum varietates superesset artifici regressus ad veniam,*
velut

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*velut emendaturo quicquid desideretur, si
non esset interceptus*.*

* Plinii Præfatio Nat. Hist. ad Divum Vespasianum.

F I N I S.



